

BHUBANANANDA ODISHA SCHOOL OF ENGINEERING, CUTTACK

DEPARTMENT OF CIVIL ENGINEERING



**LECTURE NOTE ON: Building Material & Concrete
Technology(TH 5)**

3RD SEMESTER

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CIVIL ENGINEERING DEPT BOSE, CUTTACK

CHAPTER 1 STONE



BY:-Shubhashree Maharana

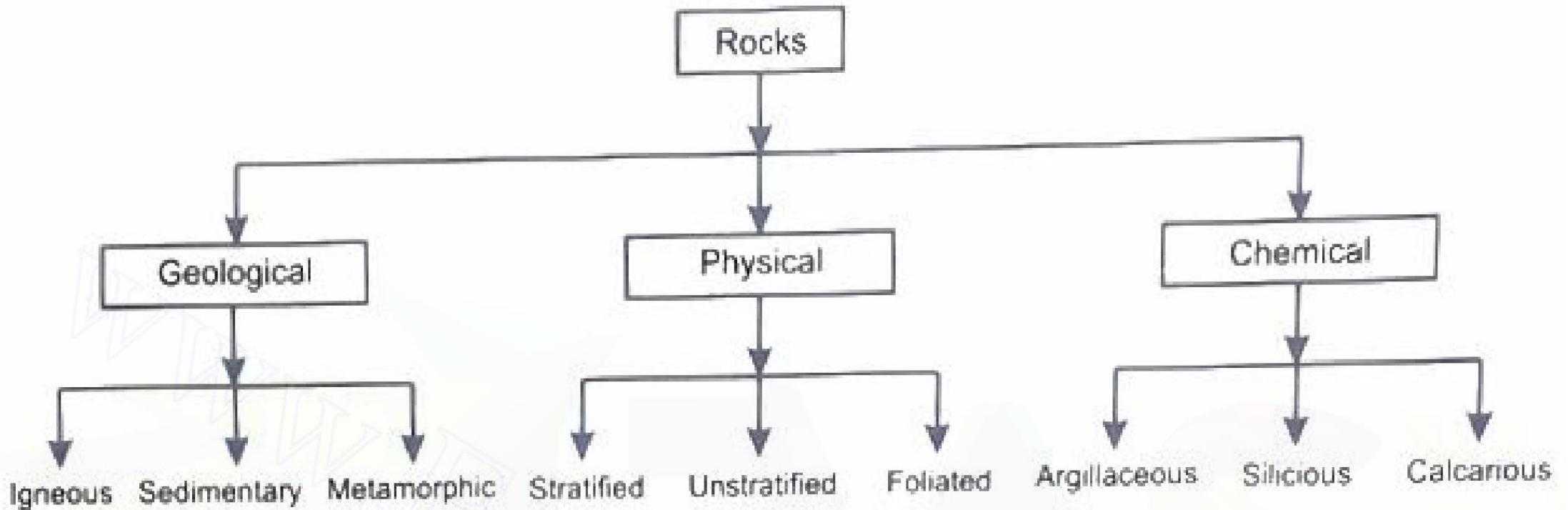


Stone

- 1.1 Classification of rock, uses of stone, natural bed of stone,
- 1.2 Qualities of good building stone,
- 1.3 Dressing of stone
- 1.4 Characteristics of different types of stone and their uses



CLASSIFICATION OF ROCK:-



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GEOLOGICAL CLASSIFICATION :-

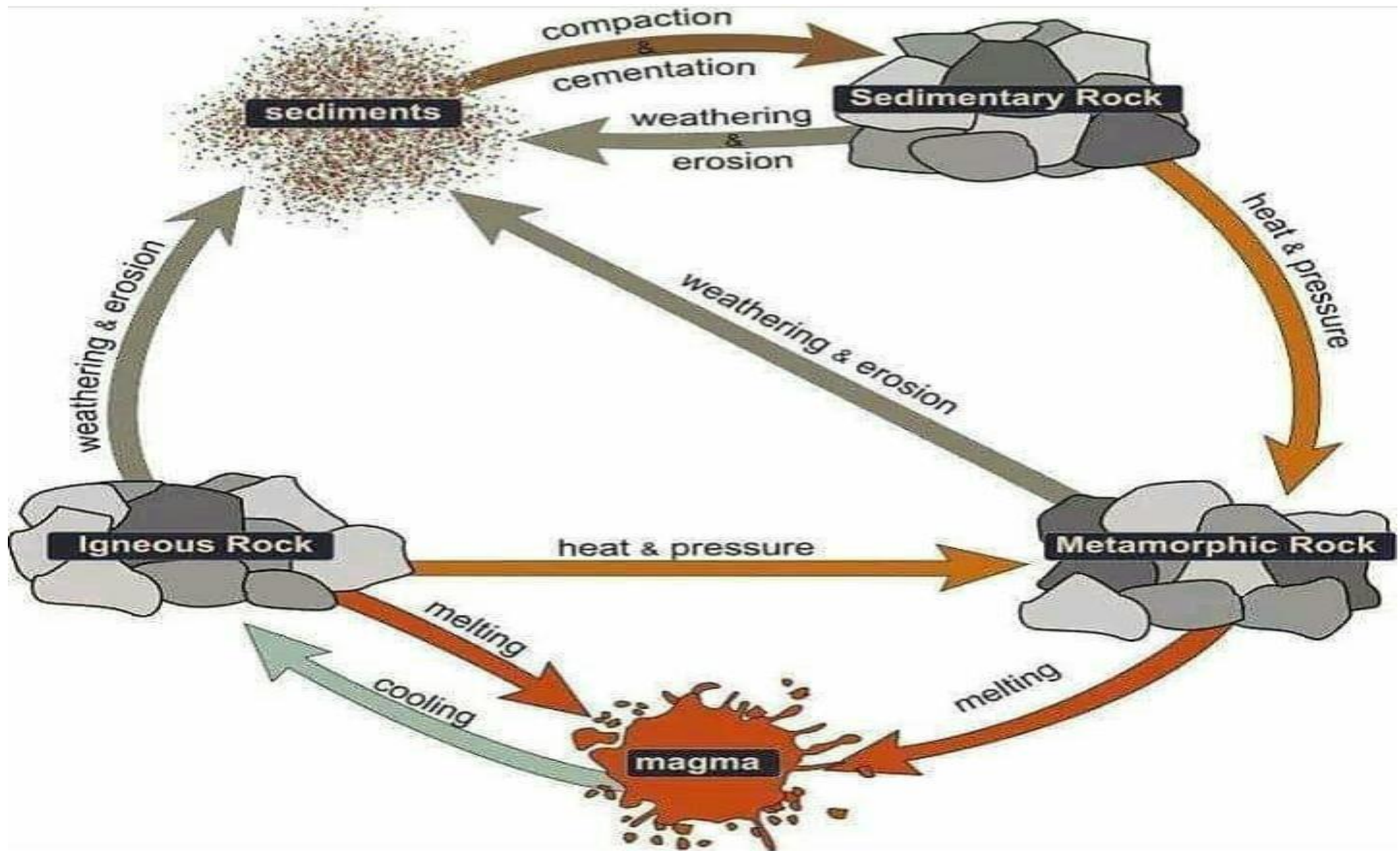
- **Igneous rocks** are formed by the solidification of magma below the earth's surface. When the magma is unable to erupt through the earth surface during its upward journey, it is held up below the earth's surface and unable to descend. This magma cools down gradually and solidifies into igneous rocks.
 1. Plutonic:- (greater depth solidification and best igneous rock) ex :- granite
 2. Volcanic:- (solidification of the rock occurs near to the earth surface and extremely fine grained structure) ex:- BASALT
 3. Hypobasal:- (shallow depth from the earth's surface & the finely grained crystalline structure of rock will be obtained) ex:- Dolerite
- **Sedimentary Rocks** formed by the deposition of sediments obtained by the weathering of pre-existing rocks and these sediments are transported by various agents such as water, wind, frost, gravity, etc.

Ex:- Sandstone, limestone, lignite, etc.

- **Metamorphic rocks** are formed by the metamorphism process. Metamorphism is the process of changing the characteristics of the pre-existing rocks under the influence of heat and pressure. The pre-existing rocks may be of the sedimentary or igneous type of rocks.

Examples: Slate, Gneiss, Schist, marble, soapstone etc.





<i>S.No.</i>	<i>Original rocks</i>	<i>Metamorphic rock</i>
1.	Granite	Gneiss
2.	Syenite	Gneiss
3.	Sandstone	Quartzite
4.	Limestone	Marble, schist
5.	Marl	Marble
6.	Shale	Slate, schist, phyllite
7.	Mudstone	Slate
8.	Dolomite	Marble
9.	Dolerite, basalt	Schist
10.	Felsite, tuff	Schist, slate
11.	Conglomerate	Gneiss, schist



Fig 2: Igneous Rock – Granite



Fig 3: Metamorphic Rock – Gneiss



PHYSICAL CLASSIFICATION

- **Stratified rocks** consist of different layers in its structure and these layers are separated by planes of stratification. These planes are also called cleavage planes or bedding planes. These rocks can easily split up along these bedding planes.

Ex:- sandstone, limestone, shale,

- **unstratified rocks** is crystalline or compact granular.
- They possess a similar kind of structure throughout their whole body. Most of the igneous rocks and some sedimentary rocks come under unstratified rocks.

Ex:- Granite, marble, trap

- **Foliated rocks** possess a layered or banded structure which is obtained by exposure of pressure and heat. Unlike the stratified rocks, these rocks can split up in a certain direction only.

examples are gneiss, schist, slate etc.



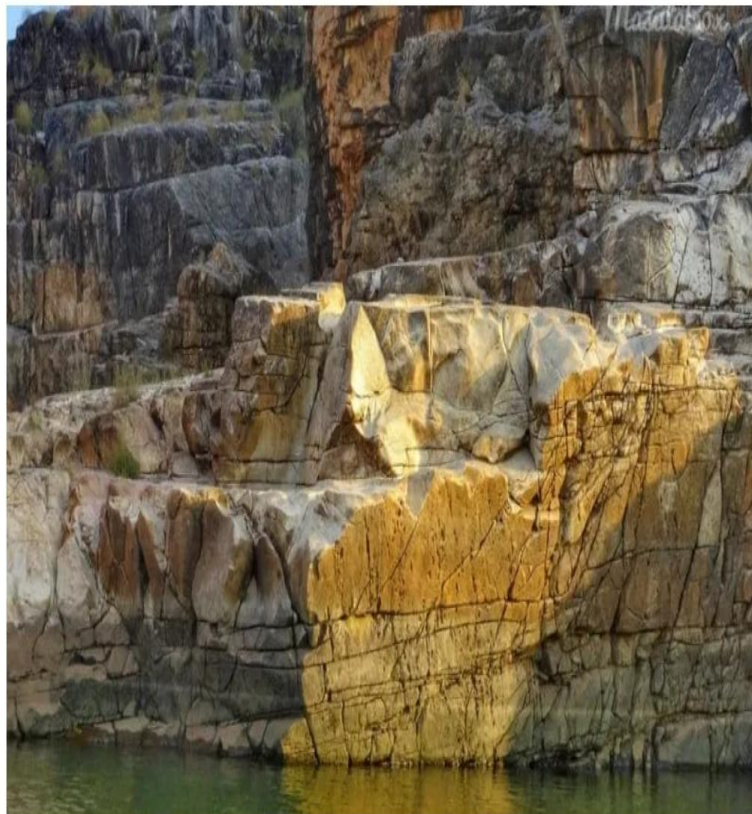


Fig 5: Unstratified Rock



Fig 6: Foliated Rock

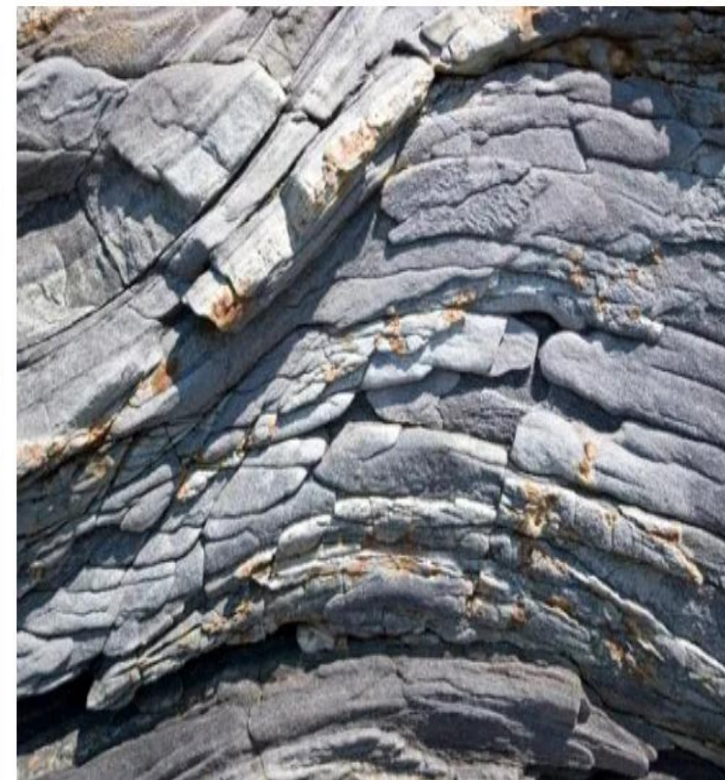


Fig 4: Stratified Rock



3. Chemical Classification: This classification is known as the scientific or engineering classification and according to this classifications, the rocks are of the following three types:

- (i) Silicious rocks
- (ii) Argillaceous rocks
- (iii) Calcareous rocks

(i) Silicious rocks: In these rocks the major constituent is silica (SiO_2) i.e. sand. The rocks are very hard and durable. e.g.: granite, basalt, trap, quartzite, gneiss, syenite etc.

(ii) Argillaceous rocks: In these rocks, the argil or clay predominates. Such rocks may be dense and compact or they may be soft. These stones are hard and durable but brittle. e.g.: slates, laterites etc.

(iii) Calcarious: In these rocks, the major constituent is lime. The durability of these rocks will depend upon the constituent present in the surrounding atmosphere. e.g. limestones, marbles, dolomite, etc.

▪ **QUALITIES OF GOOD BUILDING STONES :-** (*SWIFT CAR IS HARD, DURABLE & TOUGH*)

1. **S**pecific gravity :- minimum 2.7
2. **W**ater absorption :- must be less than 5%
3. **F**racture:- fracture should be sharp, even bright and clean with grains well cemented together.
4. **T**exture:- there should not any sign of cavities, cracks or patches of soft or loose material.
5. **C**rushing strength :- minimum 100N/mm^2
6. **A**ppearance :- must be good in appearance i.e. fine and compact structure Which is used for face work.
7. **R**esistance to fire:- it must resist fire with temp 600°C .
8. **H**ardness:- stone should not scratch when rubbed with steel ball in loss angles machine (17- Road work, 14 to 17 medium hardness and less than 14 soft stone used for ornamental work)
9. **D**urable :- must have resistance to atmospheric action
10. **T**oughness:- must have resistance against impact or sudden loading.



S.No.	Stone	Suitability	Characteristics
1.	Granite or Syenite	1. Most Suitable for important Engg. works. 2. Used for Exterior facing of buildings 3. Fine grained granite offers high resistance to weathering	1. It can be easily polished & worked 2. Excess of felspar cause Early decay. 3. Water absorption $< 1\%$
2	Marble	1. Most Suitable for Monuments, ornamental work 2. Flooring & Decorative work (Electric switch boards also)	1. Specific gravity = 2.65 2. Crushing strength = 70 N/mm ²
3	Basalt	1. Road metal & Concrete aggregates	1. High sp gr = 2.6 - 3 2. High crushing = 150-190 N/mm ²
4	Quartzite	1. Railway Ballast, Road metal & C.A	
5	Slate	1. Used in Cisterns, Damp proofings. 2. Excellent roof covering material	2. Specific gravity = 2.89 1. Crushing str = 77-210
6	Sandstone	1. Tile stone (Roofing), Flag stone (Paving) 2. Girt (Heavy work), Natural (Ornamental)	1. 2.65 - 2.95 2. 65 N/mm ² 3. Quartz + lime + silica
7	Limestone	1. Flooring, roofing & Pavings & walls. 2. In the manufacture of Lime & Cement	1. 2-2.75, 55 N/mm ² 2. Affected by frost & atmos
8	Gneiss	1. Rough stone work (like street pavings)	1. Quartz + felspar (Strong & durable)
9	Laterite	1. Very good road metal	1. Sandy clay stone
10	Kankar	1. Foundation of buildings	1. Irregular in shape 2. Impure lime stone
11	Moorum	1. Fancy paths, like garden walks.	1. Decomposed Laterite

Uses & Characteristics of stone:-

1. Basalt

- Basalt stone, which is also known as traps, is commonly used in road construction, as aggregate in concrete production, rubble masonry works for bridge piers, river walls, and dams. The basalt stone structure is medium to fine grained and compact.
- The compression strength of this stone type ranges from 200MPa to 350Mpa, and its weight is between 18KN/m^3 and 29KN/m^3 .
- Basalt has good resistant to weather, impervious to moisture, very hard, and very difficult to dress in fine shapes. The color of basalt changes from dark gray to black.

2. Granite

- The application of granite in building construction involves bridge piers, retaining walls, dams, curbs, stone columns, as coarse aggregate in concrete, ballast for railways, as damp-proof course and external cladding of walls, and monumental utilizations. The structure of granite is crystalline, fine to coarse grain.
- It is considerably hard and durable, and its compression strength ranges from 100MPa to 250MPa. It also has low absorption value, least porosity, good resistance to frost and weathering but it has poor resistance to fire. It takes polish well, and the color varies from light gray to pink. The polished granite can be used as table tops, cladding for columns and walls.

3. Sandstone

- Sandstones in combination with silica cement are used in the construction of heavy structures. It is also employed in masonry works, dams, bridge piers, and river walls. It is composed of quartz and feldspar .
- The compressive strength ranges between 20MPa and 170MPa, and specific gravity varies from 1.85 to 2.7
- It should be known that weathering sandstone makes it unsuitable for building construction.



4. Slate

- It is used as roofing tiles, slabs, and pavements. It consists of quartz, mica, and clay minerals.
- The compression strength of slate changes from 100MPa to 200MPa, and its color can be dark gray, greenish gray, purple gray to black. The structure of slate is fine grained and its specific gravity is 2.6 to 2.7.

5. Limestone

- Limestone is used for flooring, roofing, pavements and as a base material for cement. The use of limestones as facing stones should be avoided in areas where the air is polluted with industrial gases and also in coastal regions where saltish winds can attack them.

6. Laterite

- Laterite is used as building stone, but its outer surface needs to be plastered. It contains a high percentage of iron oxide and can be easily cut into blocks. Laterite occurs in soft and hard varieties.
- The compressive strength of laterite is between 1.9MPa and 2.3 Mpa.

7. Marble

- It is used for facing and ornamental works in columns, flooring, and steps. The compressive strength of marble varies from 70MPa to 75MPa.
- Marble stones are quite strong, uniform in texture, least porous, and take an excellent polish.



8. Gneiss

- This type of stone is used for minor construction since the presence of deleterious substances in its constituents makes it undesirable for building construction..The compression strength varies from 50MPa to 200MPa.
- It has fine to coarse grains, and its color may be light grey, pink, purple, greenish gray and dark grey.

9. Quartzite

- It is used as building blocks, slabs, and as aggregate for concrete. The structure of quartzite is fine to coarse grain and mostly granular and branded, and mainly composed of feldspar and mica in small quantities. The crushing strength is between 50MPa to 300MPa.



Dressing of Stone:-

- The stone dressing is a process of surfacing and shaping of rocks available naturally.
- The dressing of stone is generally done using hand tools like Chisel, Pickaxe etc using heavy machines or blasting using explosives. Once quarried, the stones are cut into the suitable size and surface finishes. This process is termed as dressing of stones.
- The effective dressing of stones would help in making your structure attractive and economical.

Different Stages Involved in Stone Dressing

Sizing :

- The irregular quarried rock is cut into desired dimensions by removing extra portions. It is generally done using hammers and chisels or cutting machines.

Shaping :

- once cut to desired dimensions extra projections are removed to shape the stone.

Plaining :

- It is the process of removing irregularities from the stone surface.

Finishing :

- It is done by rubbing the stone surface with an abrasive material like silicon carbide.

Polishing :

- In this stage the stone is polished by hand or machine to make it more attractive. It is generally done in stones like lime stones, marbles and granite.



Common type of stone dressing used in the construction field are as followed :

1. Hammer Dressing :

- Hammer dressed stones do not contain any sharp and irregular corners these stones suit well for masonry construction. These are most adopted type of dressing of stones.

2. Chisel Drafting :

- In this method the stone is made of drafts or groups with the help of chisels at different stages of dressing of stones. In this type of dressing excessive stones at the center are also removed. These stones are used commonly in plinths and corner of the building.

3. Fine Tooling :

- In this type of dressing most of the projections of the stones are removed and a fairly smooth surface is gained. Due to this the apperance of the stone improves.

4. Rough Tooling :

- In this type of dressing a rough tooled surface that has a series of bends are made of the stone. The bends are more or less parallel to tool marks make all over the surface.

5. Punched Dressing :

- This type of dressing is an extension of rough tool dressing. In this type of dressing a rough tooled surface is further dressed with the series of parallel ridges. The chisel marks are visible on the face.

6. Closed Picked Dressing :

- In this type of dressing of stone a punched stone is further dressed to obtain a finer surface.



Axed Finish of Stones

- Axe is used to get the required surface of hard stones like granite etc. This finish is called as axed finish.

Boasted Finish of Stones

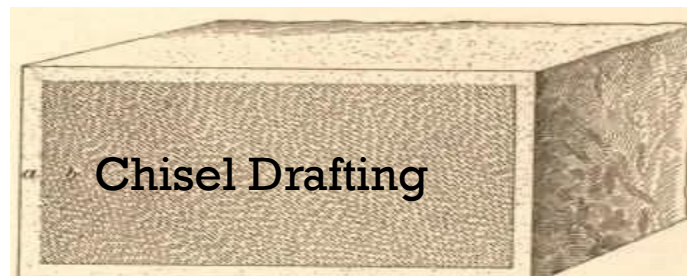
- Boasted finish is also called as droved finish. This type of finish contains intermittent parallel lines which are horizontal or vertical or inclined. This finish is obtained by a tool called boaster which have an edge of width about 60 mm.

Combed Finish of Stones

- Combed finish is suitable for soft stones. Steel comb of sharp teeth is dragged on the surface of soft stone. This is done in all directions of stone surface. This is also called as dragged finish.

Rubbed Finish for Stones

- Rubbed finish is achieved by rubbing the surface of stone with another hard surface or with suitable machine. The rubbing is fastened by using water and sand.



■ Tests for Stones

- 1. Acid Test:** To know the presence of calcium carbonate which presence make the stone less durable to weathering effects.
- 2. Attrition Test:** This test is done to find out the rate of wear resistance of stones which are used in road construction. The results of test indicates the resisting power of stones against the grinding action under traffic.
- 3. Crushing Test:-** Rate of loading given in compression testing machine 140kg/cm^2
- 4. Crystallisation Test:-** This test is done to check resistance against decay and weight loss due to weathering action.(Na_2SO_4 used for testing)
- 5. Freezing and Thawing Test:-** Done to check resistance against sun rays, wind, and rain and their adverse effects.



6. Hardness Test: Co-efficient of hardness loss in weight in gm= $(20 - \text{loss in weight}/3)$

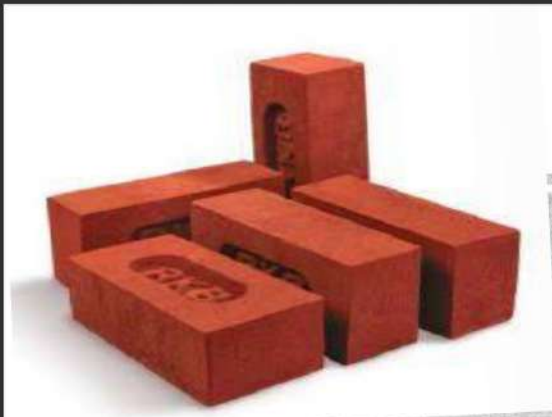
7. Impact Test : To determine toughness of a stone

8. Microscopic Test :- Done to test microscopic things like Average grain size, Existence of pores, fissures, veins and shakes, Mineral constituents, Nature of cementing material , Presence of any harmful substance, Texture of stones etc.

9. Smith's Test: This test is performed to find out the presence of soluble matter in sample of stone.

10. Water Absorption Test





CHAPTER — 2

BRICKS

BY:- Shubhashree Maharana



Bricks

2.1 Brick earth – its composition

2.2 Brick making – Preparation of brick earth, Moulding, Drying, Burning in kilns (continuous Process)

2.3 Classification of bricks, size of traditional and modular bricks, qualities of good building bricks



BRICK EARTH AND IT'S COMPOSTION:- (SALIM)

1. Silica:- A good brick earth should contains *50 to 60 % of silica*. It *prevents cracking, shrinking and warping* of raw bricks. Thus it imparts **uniform shape** to the bricks. Durability of bricks depends on the proper proportion of silica in brick earth. **Excess of silica destroys the cohesion** between particles and bricks become **brittle**.
2. Alumina:- It is the *chief constituent* of every kind of clay. A good brick earth contains *20 to 30%* of alumina. This constituent imparts **plasticity** to earth so that it can be moulded. **Excess of it causes raw bricks shrink and warp during drying and burning.**
3. Lime – A small quantity of lime is desirable in finely powdered state to **prevent shrinkage of raw bricks**. *Excess of lime causes the brick to melt* and hence, its shape is lost due to the splitting of bricks.
4. Iron Oxide- A small quantity of iron oxide to the extent of *5 to 6 percent is desirable* in good brick to impart *red colour to bricks*. *Excess of oxide of iron makes the bricks dark blue or blackish.*
5. Magnesia- A small quantity of magnesia in brick earth imparts yellow tint to bricks, and decreases shrinkage. But *excess of magnesia leads to the decay of bricks.*



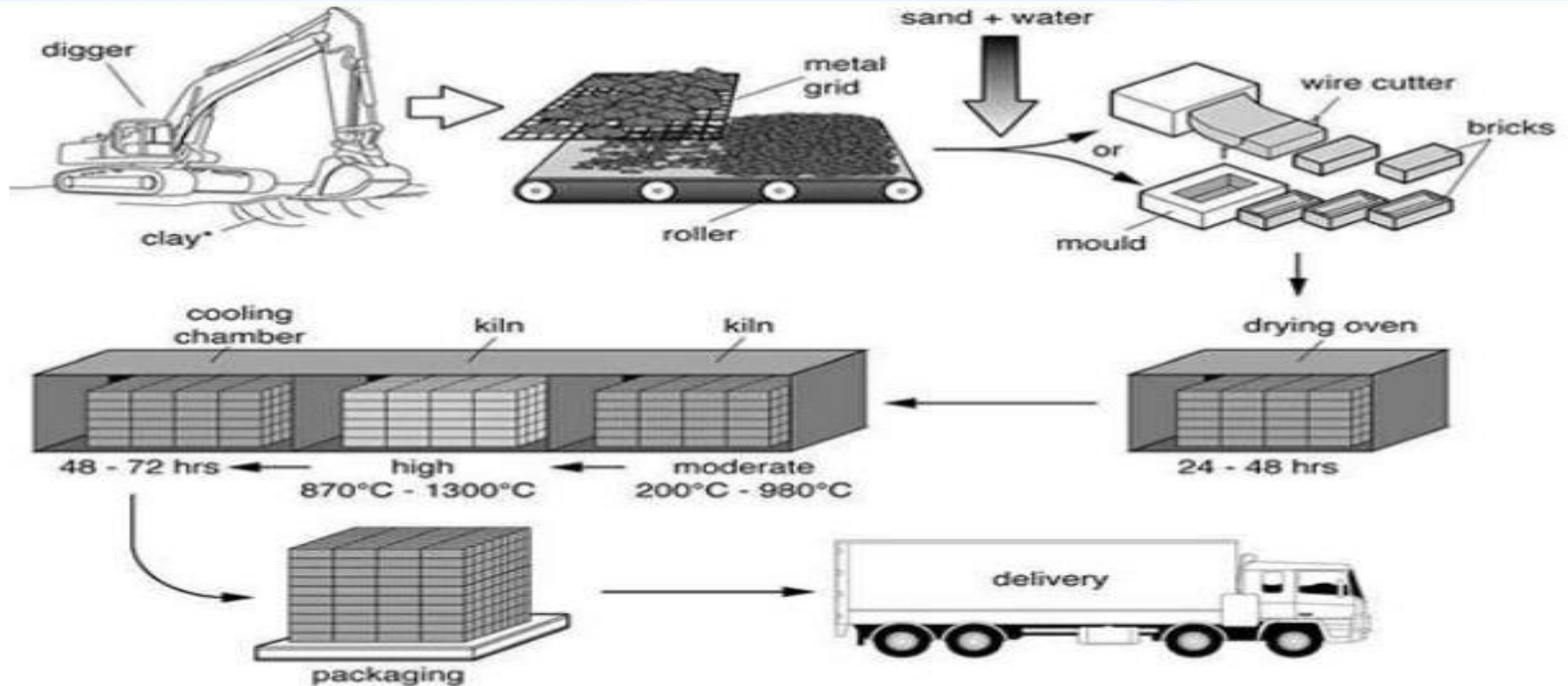
■ **Harmful Ingredients in Brick Earth:**

■ The different harmful ingredients which adversely affect the quality of brick are as follows:

1. **Lime:** makes bricks **unsound**.
2. **Iron pyrites:** it's presence makes bricks get **crystallized and disintegrated during burning**.
3. **Alkalies:** It's presence in brick makes **grey or white deposit on the wall surface**
4. **Pebbles:** Pebbles will not allow the clay to get mixed uniformly and thoroughly, which will result in weak and porous bricks.
5. **Organic Matter:** Presence of organic matter in brick earth assists in burning, but if it is not completely burnt, bricks become porous.



Preparation of BRICK:- (PMDB)



How To Make Fly Ash Bricks



Fly Ash

+



Sand

+



Lime/Chuna

+

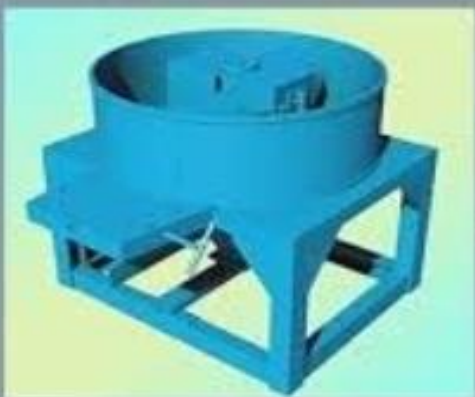


Cement

+



Water



Pan Mixture



Conveyor Belt



Main Machine

=



Bricks

4:51

I. Preparation of clay :- The preparation of clay involves following operations a.

1. **Unsoiling :-** Top layer of 20cm depth is removed as it contain impurities.
2. **Digging :** Clay dug out from ground is spread on level ground about 60cm to 120cm heaps.
3. **Cleaning :** Stones, pebbles, vegetable matter etc removed and converted into powder
4. **Weathering :-** Clay is open to atmosphere from few week to a season for softening.
5. **Blending :-** All ingredients are added and mixed properly.
6. **Tempering :-** Water in required quantity is added and the whole clay mass is kneaded or pressed under the feet of men or cattle. This is **done to obtain a homogeneous mass of clay Of uniform character**. Tempering is also done is pug mill.

process :Clay with water is placed in pug mill from the top. When the vertical staff is rotated by using electric pair, steam or diesel or turned by pair of bullocks. Clay is thoroughly mixed up by the actions of horizontal arms and knives when clay has been suffi at the bottom of tub, is opened cut and the operation

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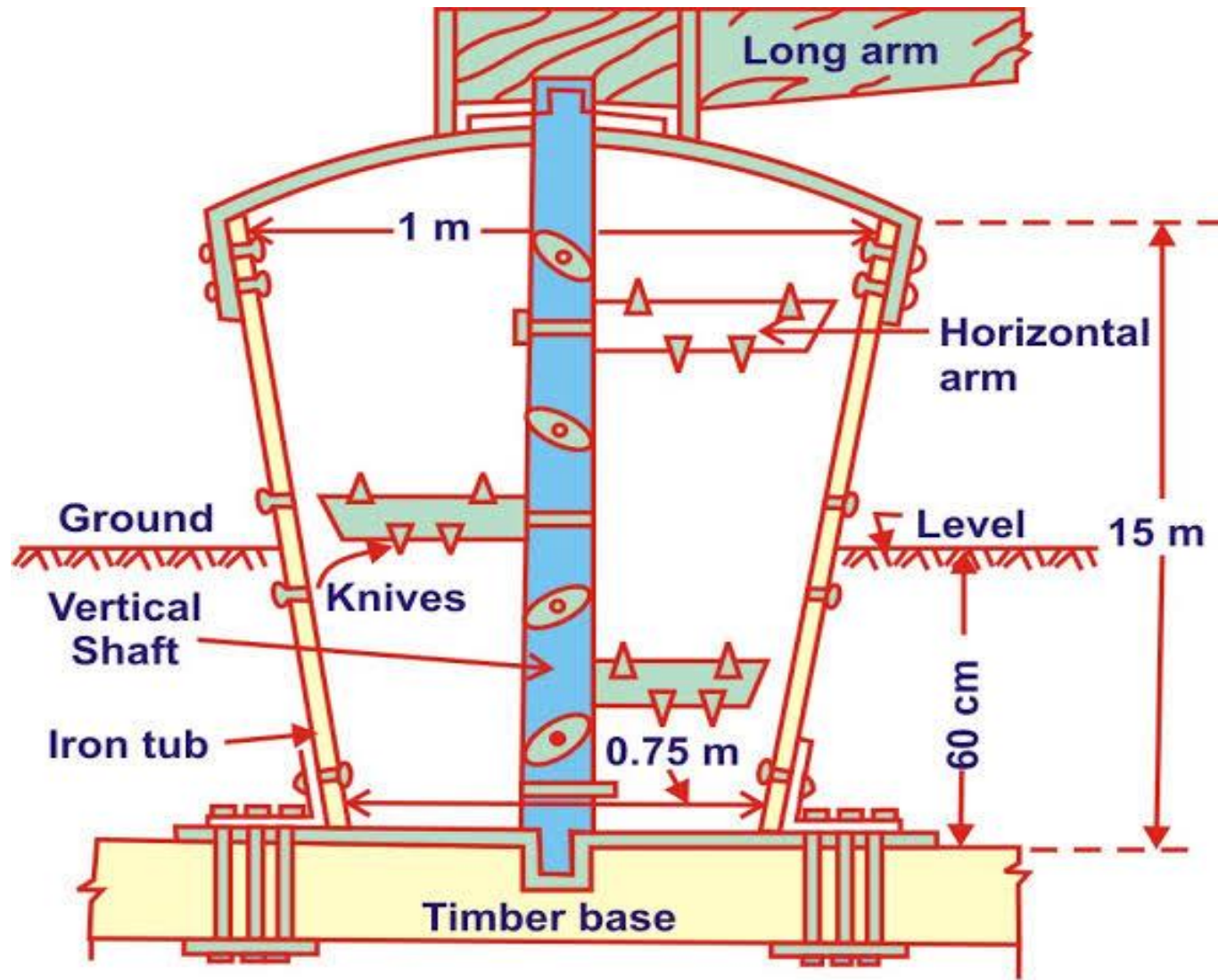
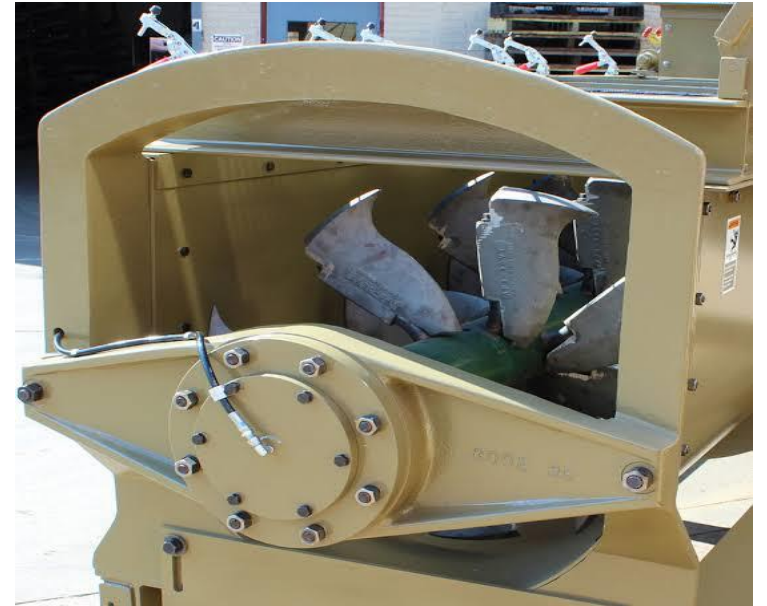


FIG. 2.1. Pug Mill.



- **Moulding** : After preparation of brick earth it's now time to give a shape to brick i.e. called moulding

a. Hand Moulding: Moulds are of wooden or steel mould used to give shape to prepared brick earth.

- Ground moulded bricks:- ground is first made level and fine sand is sprinkled over it. Mould is dipped in water and placed over the ground to fill the clay. Extra clay is removed by wooden or metal strike after the mould is filled by pressing or forcing, mould is then lifted up and raw brick is left on the ground.
- Table moulded bricks :- Process of moulding these bricks is just similar to ground bricks on a table of size about 2m x 1m

b. Machine moulding: This method proves to be economical when bricks in huge quantity are to be manufactured at the same spot. It is also helpful for moulding hard and string clay.

- Plastic clay machines :- This machine containing rectangular opening of size equal to length and width of a brick. Pugged clay is placed in the machine and as it comes out through the opening, it is cut into strips by wires fixed in frames, so these bricks are called wire cut bricks.
- Dry clay machines:- In these machines, strong clay is first converted into powder form and then water is added to form a stiff plastic paste. Such paste is placed in mould and pressed by machine to form hard and well shaped bricks. These bricks are heavier than ordinary hand moulded bricks. They carry distinct frogs and exhibit uniform texture.



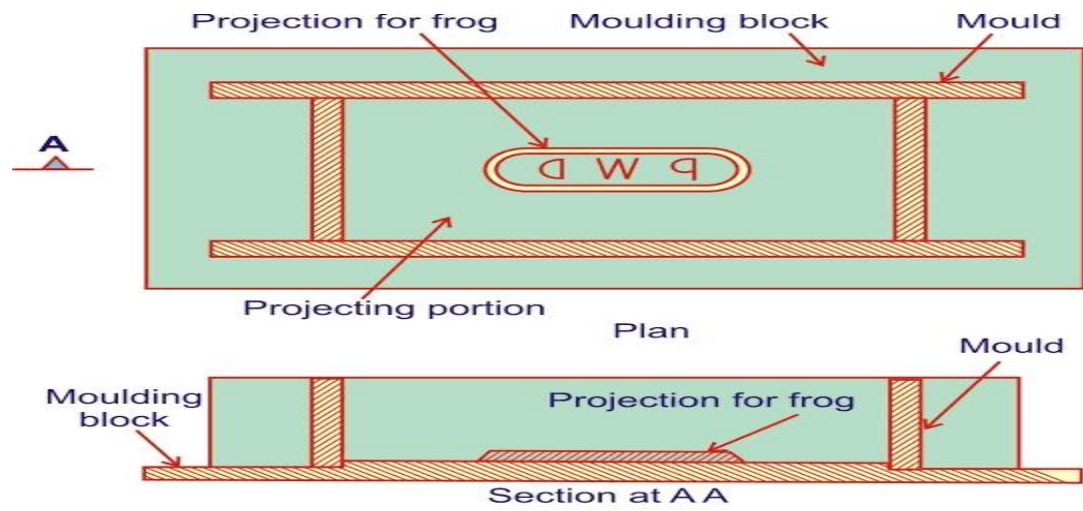


FIG. 2.4.



■ **Drying:**

1. In this stage, the moisture content is brought down to 2% before the burning operation.
2. If bricks are burnt without drying, due to sudden decrease in volume due to moisture loss. they will get distorted and cracked.
3. Drying of bricks reduce the fuel cost in burning. The bricks are generally dried by natural process. When bricks are to be rapidly dried on a large scale, then artificial drying may be adopted

■ **Burning:**

1. When the temperature of about 1100°C is reached. the particles of the constituent of bricks fuse together resulting in the increase of strength.
2. If the temperature is raised above 1100°C , a great amount of fusible glassy mass is formed and the bricks get vitrified.
3. If bricks are over burnt, they will become brittle and hence. break easily. If they are under burnt they will become soft and hence, cannot carry loads.
4. The burning of bricks can be done either in clamps or in kilns.
5. A clamp is a temporary structure which has low initial investment and are used for small scale production of bricks.
6. A Kiln is a permanent structure which has high initial investment and are adopted to manufacture bricks on a large scale.



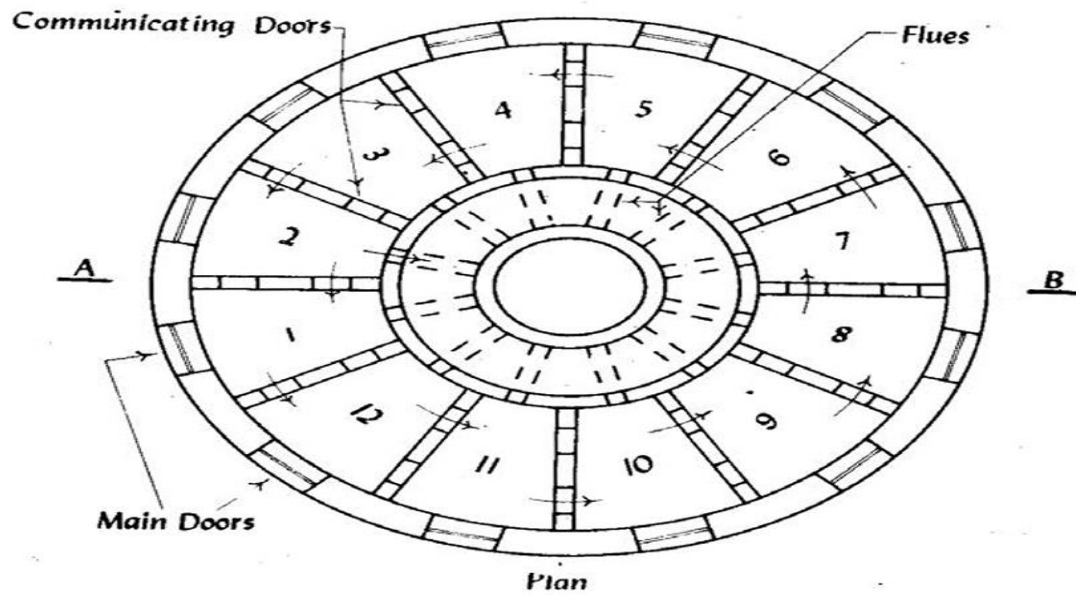
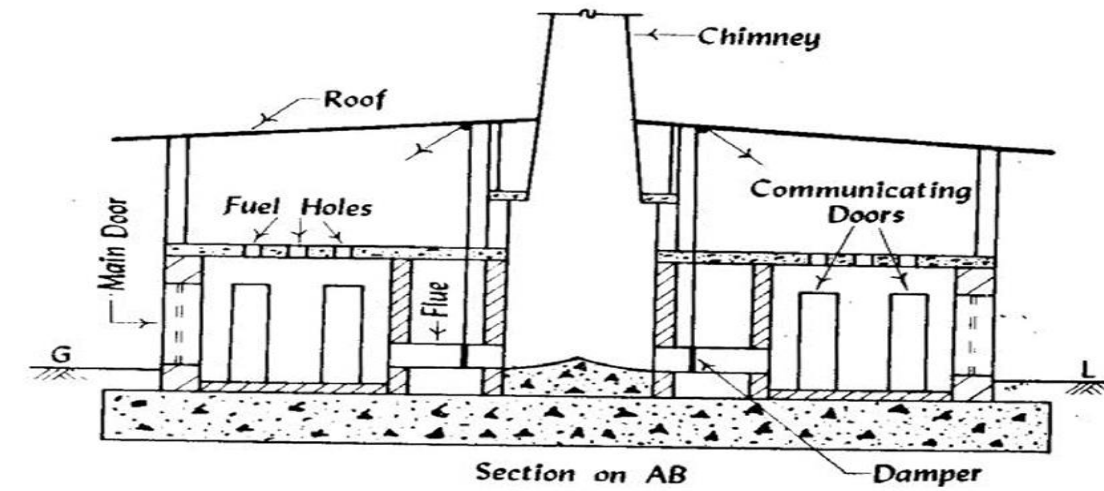


Fig : Hoffman's kiln

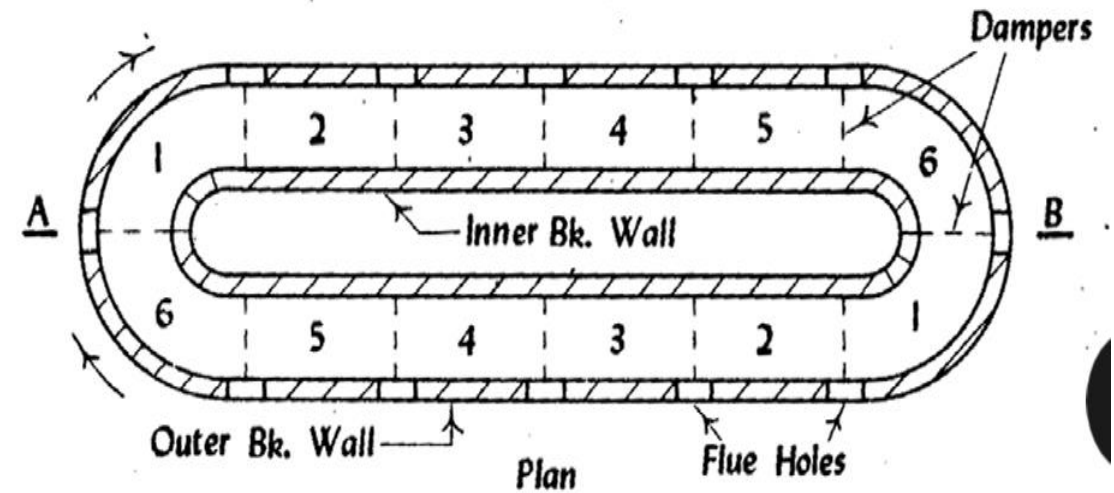
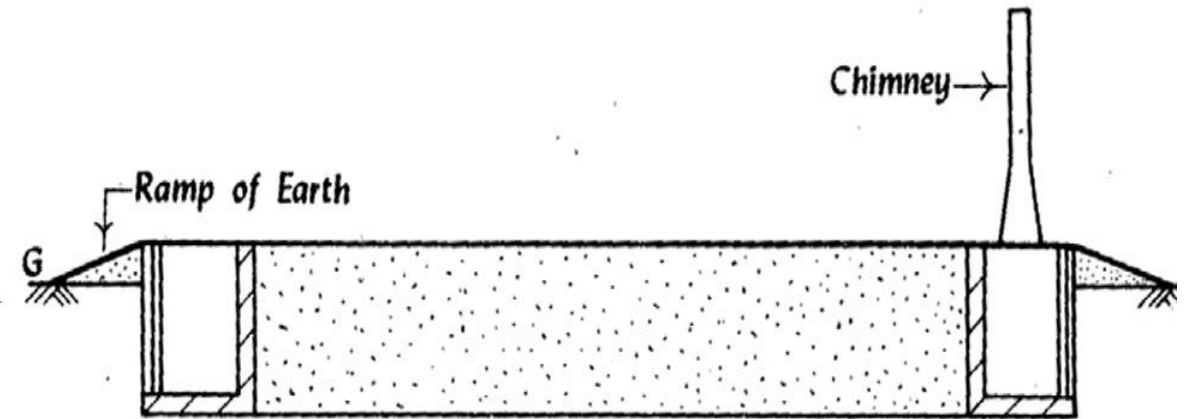


Fig ; bulls trench kiln





Continuous Kiln:

- The examples of continuous kiln are Hoffman's kiln and Bull's trench kiln .
 - In a continuous kiln, bricks are stacked in various chambers wherein the bricks undergo different treatments at the same time.
 - When the bricks in one of the chambers is fired, the bricks in the next set of chambers are dried and preheated while bricks in the other set of chambers are loaded and in the last are cooled.
1. Chamber 1 – loading
 2. Chamber 2 to 5 – drying and pre-heating
 3. Chambers 6 and 7 – burning
 4. Chambers 8 to 11 – cooling
 5. Chamber 12 – unloading



- The initial cost in stalling this kiln is high,
- The following **advantages**
 - i. Good quality of bricks are produced.
 - ii. It is possible to regulate heat inside the chambers through fuel holes.
 - iii. Supply of bricks is continuous and regular.
 - iv. There is considerable saving in fuel due to pre heating of raw bricks by flue gases Such a kiln will manufacture about 25000 bricks daily or about 8 to 9 million brick



■ **Classification of Bricks:**

- The bricks can broadly be divided into two categories:

(a) **Unburnt Bricks:**

- The unburnt or sun dried bricks are dried with the help of heat from the sun after the process of moulding.
- These bricks are of low quality and are used in the construction of temporary and cheap structures. Such bricks should not be used at places exposed to heavy rains.

(b) **Burnt Bricks:** These bricks are classified into four types:

1. First Class Bricks:

- These bricks are table moulded and of standard shape.
- Minimum compressive strength 10N/mm^2 and water absorption should not more than 20% by weight of brick
- They are burnt in kilns. The edges of the bricks are sharp, square and straight.
- These bricks are used for superior works of permanent nature.
- These bricks can be used for the construction of load bearing structures and places where the brick work is not coated with plaster.

2. Second class bricks:

- These bricks are ground moulded and they are burnt in kilns.
- Minimum Compressive strength 7.5 N/mm^2 , and water absorption should not more than 22% by weight of brick
- The surface of bricks is somewhat rough and shape is also slightly irregular.
- These bricks are commonly used at places where brick work is to be provided with a coat of plaster.



3. Third Class Bricks:

- These bricks are ground moulded and burned in clamps.
- Minimum compressive strength 5 N/mm^2 , and water absorption should not more than 25% by weight of brick.
- These bricks are not hard and they have rough surface with irregular and distorted edges.
- These bricks give dull sound when struck together.
- They bricks are used for unimportant and temporary structures.

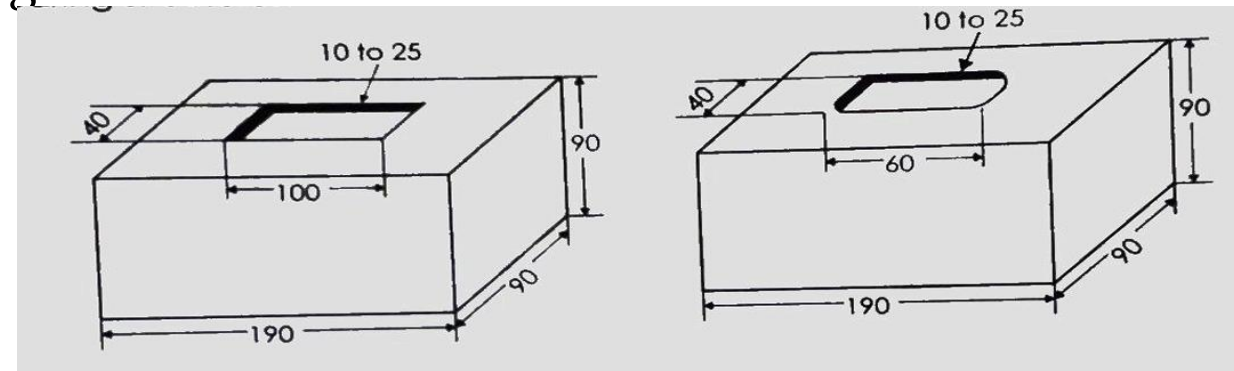
4. Fourth Class Bricks:

- These are over burnt bricks with irregular shape and dark colour.
- These bricks can be used as aggregates for concrete in foundations, floors, roads, etc.

Based on size :- Bricks are divided in to two categories

1. Traditional brick :- $23\text{cm} \times 11\text{cm} \times 8\text{cm}$

2. Modular brick:- $19\text{cm} \times 9\text{cm} \times 9\text{cm}$.





■ Qualities of Good Bricks:

1. They should be **table-moulded**, well-burnt in kilns, copper-coloured free from cracks and with sharp and square edges.
2. Their **colour** should be **uniform and bright**.
3. They should be of **uniform shape** and should be of *standard size*.
4. They should give a **clear metallic ringing** sound when struck with each other.
5. When broken they should show a bright homogeneous and **uniform compact structure** free of voids.
6. **No impression should be left on brick surface**, when it is scratched with finger or nail.
7. They **should not break when dropped** flat on hard ground from a height of about meter.
8. When soaked in water for 24 hours, they **should not show deposits of white salts** when allowed to dry in shade.
9. Minimum compressive strength of brick is 3.5 N/mm^2
10. Maximum water absorption should not exceed 25% of weight of dry brick.



■ Tests for Bricks:

- (I) Water Absorption Test: 24 Hour Immersion cold water test: A brick is taken and it is weighed dry. It is then immersed in water at 27 °C for a period of 24 hours.

The value should not exceed

1. 20 percent for first class bricks.
2. 22.5 percent for second class bricks.
3. 25 percent for third class bricks.

(II) Crushing Strength Test:

The crushing strength for **first class** bricks should **not be less than 10.5 N/mm²** and for **second class** bricks it should **not be less than 7.5 N/mm²**.

(III) Hardness Test:

In this test a scratch is made on the brick surface with finger or nail. If no impression is made on the surface, then the brick can be considered to be sufficiently hard.



(IV) Emorescence Test:

Bricks are kept in a 150mm dia glass dish containing 25 mm depth of water at room temperature. On drying, gray or white powder patches appear on brick surface.

Efflorescence is classified as:

- Nil: If the deposit of efflorescence is imperceptible.
- Slight: If efflorescence is less than 10% of exposed brick area.
- Moderate: If efflorescence is between 10 and 50% of exposed brick area.
- Serious: If deposits are heavy and powder or flaks are formed on the brick surface.
- Heavy: If efflorescence is more than 50% of the exposed brick area. For any class of brick, efflorescence should not be more than moderate condition.

(V) Warping Test:

Measured with the help of a flat stool or glass surface. The greatest distance of brick surface from the edge of straightness is measured in this test.

There are two types of warpage I. Concave warping. Convex warping.

(VI) Soundness Test:

In this test, two bricks are taken and they are struck with each other. The bricks should not break and a clear ringing sound should be produced.





CHAPTER 3

CEMENT ,MOTAR, AND CONCRETE

BY:-Shubhashree Maharana



CEMENT, MORTAR AND CONCRETE

3.1 Cement: Types of cements, Properties of cements, Manufacturing of cement

3.2 Importance and application of blended cement with fly ash and blast furnace slag.

3.3 Mortar: Definition and types of mortar

3.4 Sources and classification of sand, Bulking of sand

3.5 Use of gravel, morrum and fly ash as different building material

3.6 Concrete: Definition and composition- Water cement ratio- Workability, mechanical properties and grading of aggregates, mixing, placing, compacting and curing of concrete.



Constituent Of Cement:-

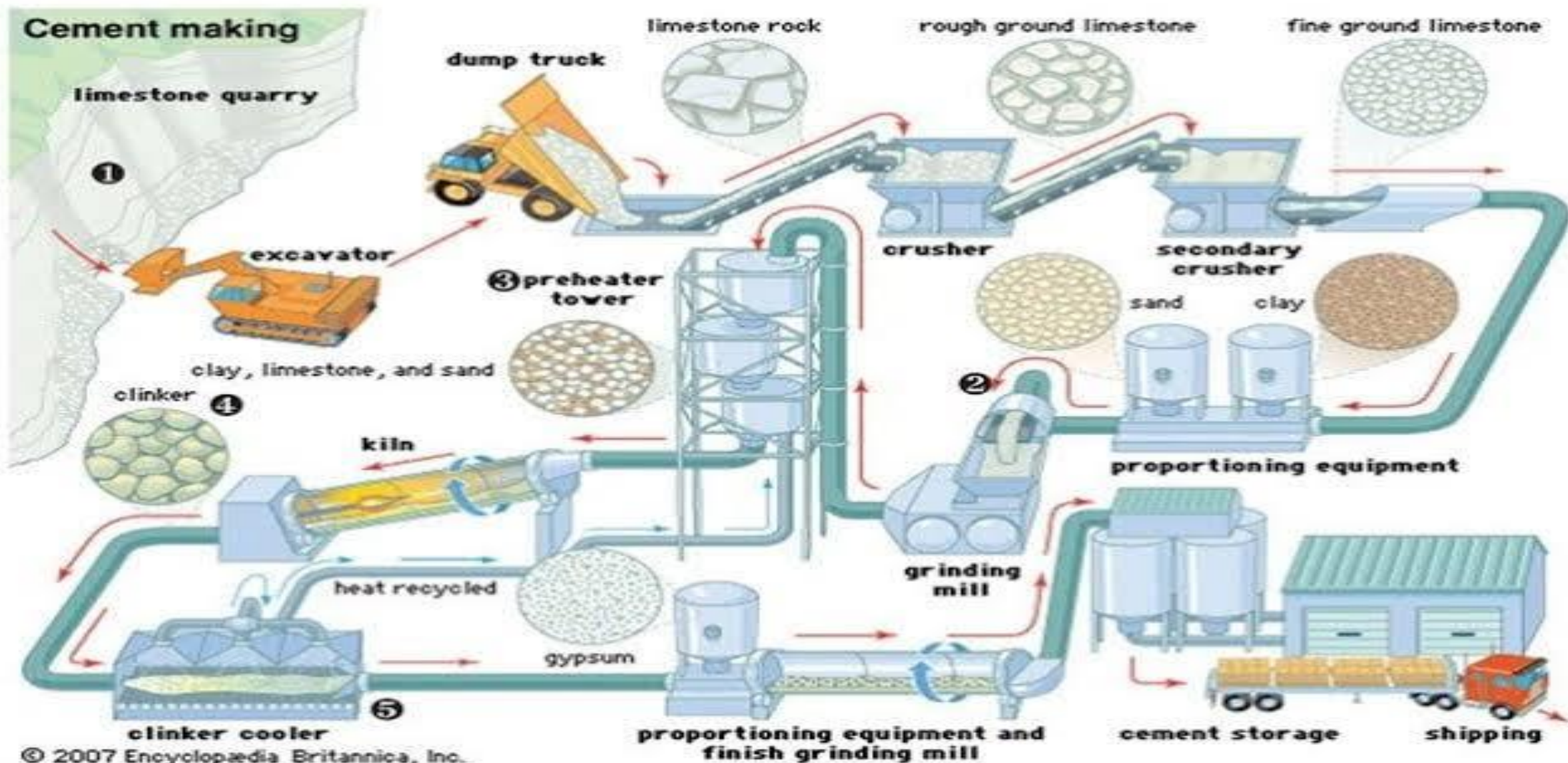
- Lime:- (60-65%) controls strength and soundness properties, excess causes unsoundness of cement, deficiency causes less strength.
- Silica:- (17-25%) imparts strength to cement, by forming C_2S & C_3S . Excess Strength of cement increases and setting time prolonged.
- Alumina:- (3-8%) it acts as a flux and reduces the temperature of clinker and imparts quick setting property.
- Calcium sulphate:- it is in the form of Gypsum and increase setting time of cement.
- Iron oxide:- (0.5-6%) imparts colour and act as a catalyst in fusion of different ingredients of cement.
- Magnesia:- (0.1-4%) imparts hardness and colour, excess causes unsoundness.
- Alkalies :- present a small amount.

HYDRATION OF CEMENT:-

- The chemical reaction takes place between Cement and Water is known as hydration of cement. In this reaction process a large amount of heat liberated which initiate setting of cement.
- If cement is grounded very finely, then heat of hydration will more and cement sets quickly which leads flash setting of cement.



Cement making



Bogue Compounds:-

- **Tricalcium Silicate (C3S):** This compound is supposed to have the best cementing properties among the different compounds of cement. It has high rate of hydrolysis and is responsible for 7 day hardness and strength of cement. However, high C3S content leads to high heat of hydration. It has a heat of hydration of about 500 J/gm.
- **Dicalcium Silicate (C2S):** This compound hydrates and hardens slowly and takes longer time to contribute to the strength compared to C3S. But in a period of one year, its contribution to the strength and hardness is proportionately equal to C3A. It also imparts resistance to chemical attack, as the hydration of this compound releases less compared to C3A. However, high C2S content reduces the rate of early strength gain, decreases resistance to freezing and thawing and decreases the heat of hydration. It has a heat of hydration of about 260 J/gm.
- **Tricalcium Aluminate (C3A):** This compound rapidly reacts with water and may lead to immediate stiffening of the cement paste, known as flash set. This action is regulated by the addition of 2 — 3 % gypsum at the time of grinding of clinkers. It is responsible for the initial set, a greater tendency to volume changes causing cracking and has high heat of hydration. Raising the C3A content reduces the setting time, weakens resistance to sulphate attack and lowers the ultimate strength. It has a heat of hydration of about 865 J/gm.
- **Tetracalcium Aluminoferrite (C4AF):** This compound has poor cementing value and is also responsible for flash set, but to a lesser extent compared to C3A. It generates less heat of hydration compared to C3A. It has a heat of hydration of about 420 J/gm.



TYPES OF CEMENT:-

I. Ordinary Portland Cement (OPC):

- The ordinary Portland cement, or the setting cement is the basic Portland cement and is manufactured in large quantities compared to any other type of cement.
- It is available in the market in three different grades, 33 Grade, 43 Grade and 53 Grade. The numbers 33, 43 and 53 correspond to the 28 day (Characteristic) compressive strength of cement as obtained from standard tests on cement-sand mortar cube specimens.
- It is used in general concrete construction where there is no exposure to sulphates in the soil or in ground water.
 - 33 grade - IS:269 - 1989
 - 43 grade - IS:81 12- 1989
 - 53 grade - IS:12269- 1987
- Higher grades are achieved by increasing the proportion of lime and grinding the clinkers more finely.

II. Rapid Hardening cement (RHC) (IS: 8041: 1990):

- This cement has more proportions of C_3S compared to C_2S and is ground finer than OPC.
- This cement has high rate of early strength gain. The 1 day strength of this cement is equal to the 3 day strength of OPC, but the setting times of both the cements are the same.
- Because of this high rate of early strength gain, the formwork can be stripped much early, saving considerable time and money.
- As this cement matures quickly, it has higher resistance to Freezing and Thawing effects compared to OPC.



III. Extra Rapid Hardening Cement (ERHC):

- This cement is also known as *calcium chloride cement* as this cement is obtained by mixing calcium chloride (not exceeding 2% by weight) with rapid hardening cement.
- The **I day strength** of extra rapid hardening cement is **25% more than that of rapid hardening cement**.
- The acceleration of setting, hardening and high heat of hydration in the early periods make this cement very suitable for concreting in cold weather conditions.
- Use of this cement is prohibited in **pre-stressed concrete constructions**.

IV. Low Heat Cement (LHC) (IS: 12600-1989):-

- This cement is obtained by reducing the proportions of C_3S and C_3A and increasing the proportion of C_2S
- As the rate of gain of strength of this cement is slow, adequate precautions must be taken while removing the form work.
- Because of its low heat of hydration, this cement can be used in works like construction of abutments, retaining walls, dams, etc. where mass concreting is done.

V. Blast Furnace Slag Cement (IS: 455 - 1989):-

- Blast Furnace Slag cement(which has oxides of Lime, Silica and Alumina.) is manufactured by inter-grinding granulated blast furnace slag with Portland cement clinkers. The proportion of the slag should not be less than 25% or more than 65% by weight of the total mixture.
- It has lower rate of strength gain compared to ordinary Portland cement, but the setting times of both the cements are the same.
- As this cement has high sulphate resistance, it is suitable for the construction of concrete structures which are exposed to sulphates like foundations, marine structures, etc.
- This cement has low heat of evolution compared to ordinary Portland cement, thus it can be used in mass concrete structures such as dams, foundations and bridge abutments.



VI. Portland Pozzolana Cement (PPC) (IS: 1489-1991 Part 1 and 2)

- IS: 1489-1991 Part I deals with the manufacture, physical and chemical requirements of Portland Pozzolana cement using only fly ash pozzolana.
- IS: 1489-1991 Part 2 deals with the manufacture, physical and chemical requirements of Portland Pozzolana cement using calcined clay pozzolana or a mixture of calcined clay and fly ash pozzolana.
- This cement can be produced either by grinding together of Portland cement clinkers with pozzolanic material along with the addition of gypsum or by directly mixing Portland cement with fine pozzolanic material.
- A pozzolanic material in itself possess no cementitious properties, but in the presence of water it reacts with calcium hydroxide, liberated in the hydration process, to produce compounds possessing cementitious properties. This property is known as pozzolanic action.
- $\text{Ca(OH)}_2 + \text{Pozzolana} + \text{Water} \rightarrow \text{C-S-H (gel)}$
- *Because of the absence of this cement has higher resistance to chemical agencies and to sea water, thus Useful in marine and hydraulic constructions.*
- *As PPC produces less heat of hydration, it can be used in the construction of structures requiring mass concreting. (Ex: Abutments, Dams, Bridges, etc)*
- *This cement has less heat of evolution and lower rate of early strength gain compared to that of OPC, but has the same ultimate strength.*

VII. super Sulphate Cement (IS: 6909-1990):-

- This cement is manufactured by finely grinding a mixture of 80 to 85% of granulated slag, 10 to 15% of calcium sulphate and 5% of cement clinkers.
- This cement has a very low percentage of C_3A , thus making it highly resistant against sulphate attack.
- This cement has low heat of evolutions, thus making it useful in the construction of structures requiring mass concreting.



VIII. Sulphate Resisting Cement (SRC) (IS: 12330-1988):-

- This cement has very low percentage of C_3A and is grounded finer than ordinary Portland cement.
- This cement can also be manufactured by adding extra iron oxide, which combines with alumina to form C_4AF , which does not react with sulphate salts.
- Because of the very low percentage of C_3A , the disintegration of concrete caused by the reaction of C_3A with sulphate salts is inhibited. rendering the cement resistant to sulphate attack.
- This cement is used for the construction of structures such as marine structures, sewage treatment works and foundations.
- The use of this cement has to be restricted in environments where chlorides are present.

IX. White Portland Cement (IS: 8042-2015)

- The greyish colour of OPC is due to iron oxide.
- In the manufacturing of this cement, the proportion of Iron oxide is limited by using chalk and china clay as raw materials, which have low percentages of iron oxide.
- In the absence of Iron oxide, Sodium Alumino Ferrite (Cryolite) Na_3AlF_6 is added to act as flux for the fusion of different ingredients of cement.
- The properties of white cement are same as that of ordinary Portland cement.
- Whiteness of white cement is measured by ISI scale or Hunter's scale.
- The whiteness should not be less than 70% on ISI scale and on Hunter's scale it is generally 90%
- Colouring agents can be added to white cement to produce coloured cement.

X. lumina cement (HAC) (IS: 6452-1989):-

- This cement is characterized by its dark colour high early strength high heat of hydration and more resistance against chemical attack.
- The raw materials used for the manufacturing of this cement are Bauxite (a special type of which has high alumina content), limestone, silica, iron oxide, etc.



- The main advantage is that it can **withstand high temperatures**, so that it can be used in refractories, foundries and other workshops where high temperatures are involved.
- For this cement, the initial setting time is around 3 hours and the final setting time is around 5 hours.
- This cement has **high heat of evolution** and thus can be used in **constructions in cold weather conditions**.
- Since no free hydrated lime is produced in the hydration of this cement, this cement is highly **resistant against chemical and sulphate attack**.
- Since the raw material bauxite is very costly. **High alumina cement is very expensive** to manufacture.

XI. Hydrophobic Cement (IS: 8043-1991):-

- This cement is obtained by inter-grinding OPC clinkers with 0.1 - 0.4 % of water repellent film forming substances like oleic acid or stearic acid.
- These substances help in reducing the rate of deterioration of the cement during long storage, storage in humid places, during transportation, or under other unfavourable conditions.

XII. Masonry Cement (IS: 3466-1988):-

- This cement is manufactured by inter-grinding OPC clinkers with hydrated lime, granulated blast furnace slag or crushed stone.
- This cement gives good workability, reduced shrinkage and has good water retention property. When OPC is used, due to its less water retentively, the masonry absorbs water from the cement mortar resulting in poor bonding. This problem can be eliminated by using Masonry cement.



XIII. Air Entertaining Cement:-

- This cement is manufactured by grounding small quantities (around 0.1% by weight) of air entraining agents with ordinary Portland cement clinkers.
- Resins, vegetable fats and oils, fatty acids are the most commonly used air entraining agents.
- These materials entrain air in the cement in the form of tiny air bubbles.
- Use of this cement improves the workability of concrete. Thus w/c cement ratio can be reduced and produce higher grades of cement.
- The tiny voids formed after setting helps in improving the freezing and thawing resistance of cement.

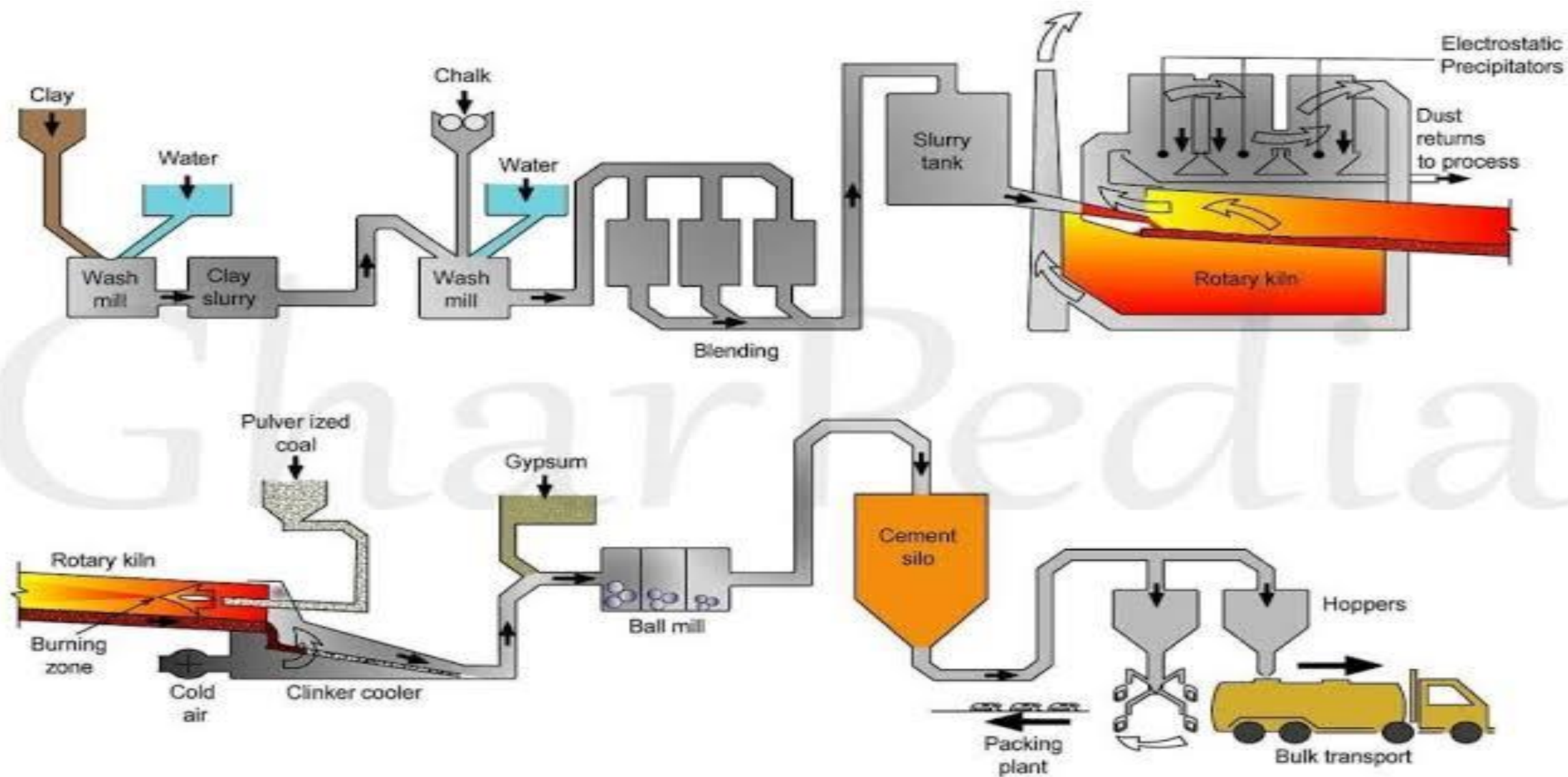
Manufacturing of Ordinary Portland Cement:

There are ***two types of processes*** commonly employed for the manufacturing of cement, they are ***dry and wet processes***.

1. wet process,

- the limestone brought from the quarries is first crushed to smaller fragments.
- Then it is taken into a ball or tube mill where it is mixed with clay or shale, as the case may be, and grounded to a fine consistency of slurry with the addition of water.
- The slurry is stored in tanks under constant agitation and fed into huge firebrick lined rotary kilns.



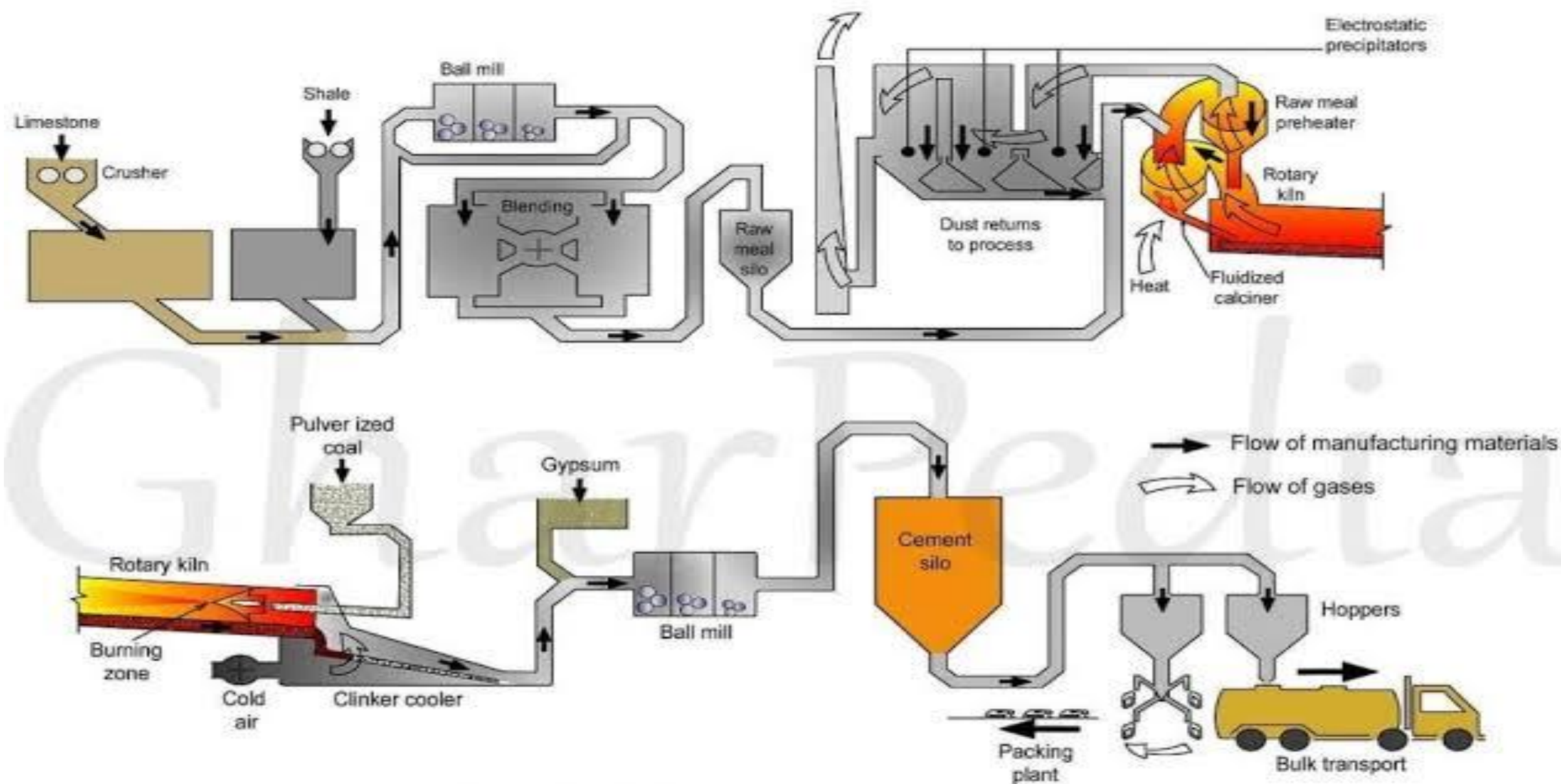


Wet Process for Manufacturing of Cement

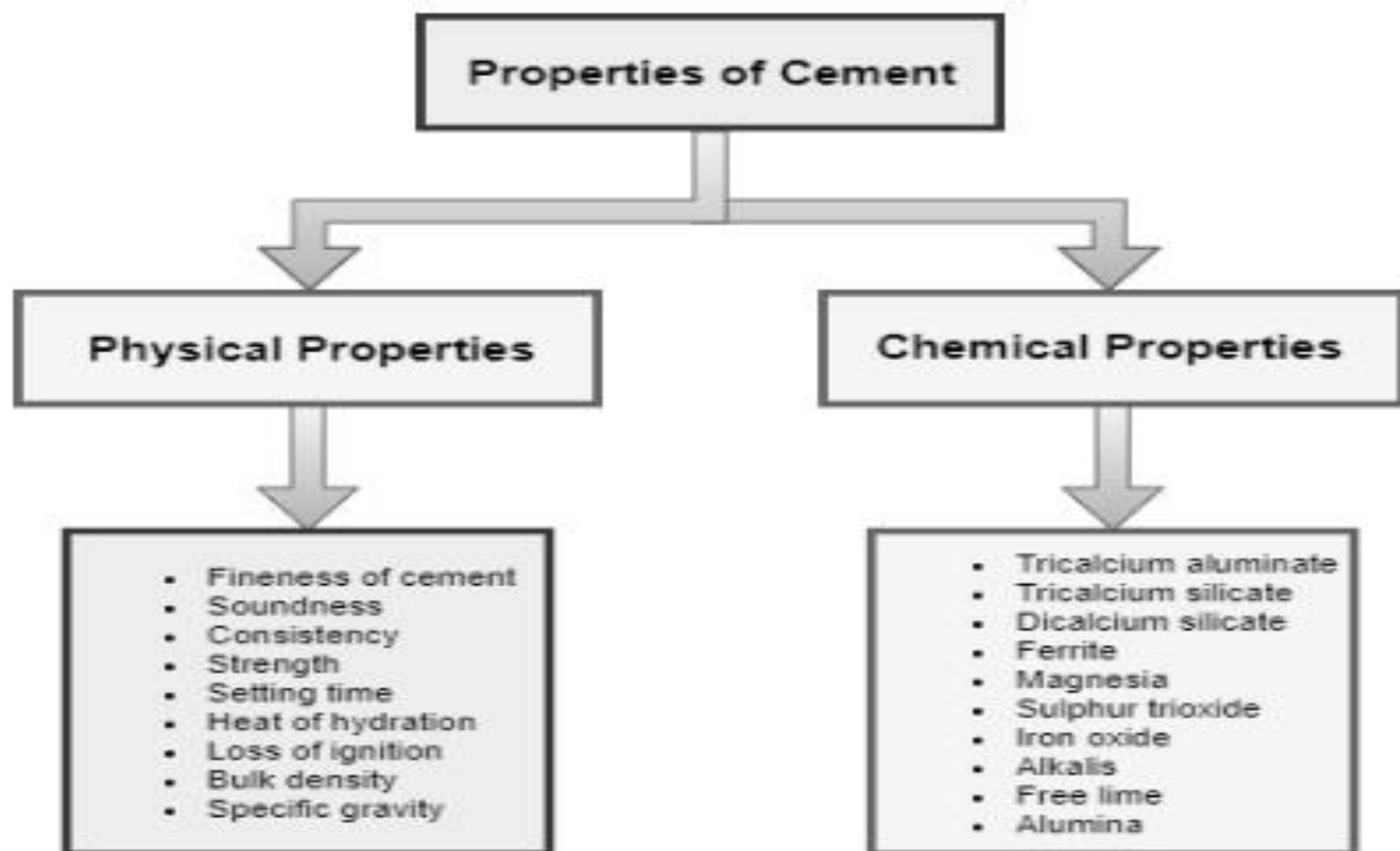
2. ***dry process,***

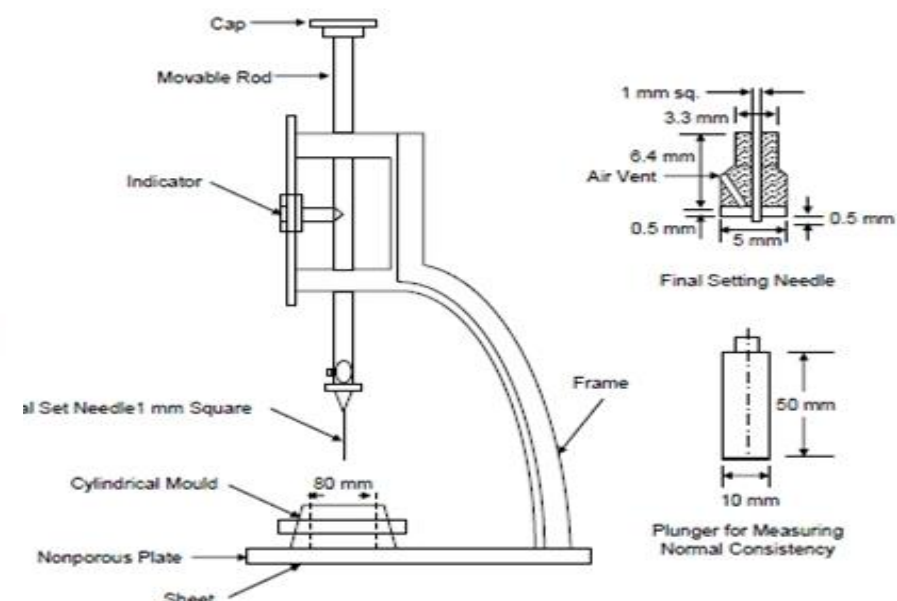
- The raw materials are grounded, mixed and fed into the rotary kilns in the dry state itself.
- By the time the material rolls down to the lower end of the rotary kiln, it undergoes a series of chemical reactions until finally, in the hottest part of the kiln where the temperature is of the order of 1500°C. about 20 to 30 percent of the material gets fused.
- The fused mass turns into ***nodular form of size 3 mm to 20 mm, known as clinker.***
- Clinker has its own physical and chemical properties.
- This ***clinker is coated, crushed, mixed with 3 to 5 percent of gypsum*** and fed into a tube mill for final grinding. The finished product. known as Portland cement. is packed in bags weighing 50 Kg per



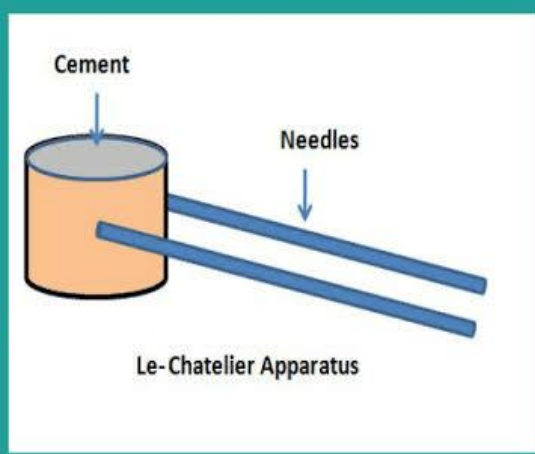
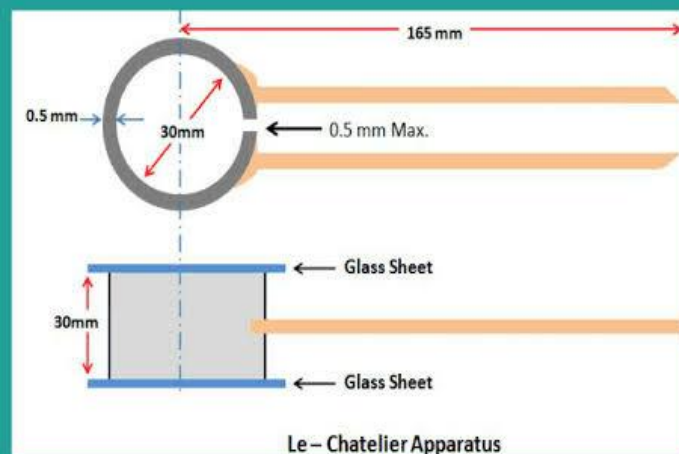


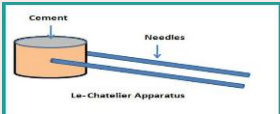
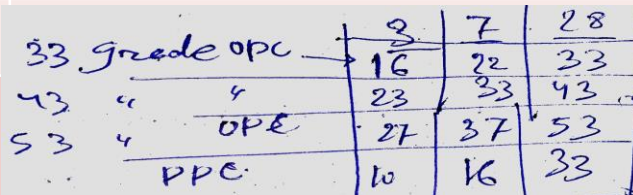
Dry Process for Manufacturing of Cement





Soundness Test of Cement



TEST NAME	Apparatus Required	Water to be added	IS value
Fineness Test	IS SIEVE 90micron size 		Residues left on sieve not more than 10% by weight of cement
Soundness Test	LeChartliers apparatus 	0.78 times consistency of Cement	Expansion between the legs should not exceed 5mm
Consistency of Cement	Vicat Apparatus with plunger 	Approximately to make a cement paste (25 to 33% by weight of cement)	The standard consistency of cement is that water content which permit the vicat plunger to penetrate to a point 5 to 7mm from the bottom of the vicat mould when tested
Initial setting Time	Vicat apparatus With needle	85%(0.85) of standard consistency of cement	Not less than 30min
Final Setting time	Vicat apparatus Needle with annular collar 	Further process from initial setting time (no more water to be added)	Between 6 to 10 hour
Specific Gravity	Density bottle 	As per definition	
Compressive strength (Determines grade of	Compression testing machines and 70.6mm size	(P/4 +0.3) P= % of consistency	

Properties of cements:-

- Following are the **physical, mechanical and chemical** properties of cement.

1. Physical properties of cement:-

Following are the important physical properties of a good cement which primarily depends upon its chemical composition, thoroughness of burning and fineness of grinding

- It gives *strength* to the masonry.
- It is an *excellent binding material*.
- It is easily *workable*.
- It offers good *resistance to the moisture*.
- It possesses a *good plasticity*.
- It stiffens or *hardens early*.
- A thin paste of cement with water should feel sticky between the fingers.
- A cement thrown in water should sink and should not float on the surface.
- The particles should have uniformity of fineness. Specific surface area should not be less than $2250 \text{ cm}^2/\text{gm}$.
- The initial setting time for ordinary Portland cement is about 30 minutes
- The final setting time for ordinary Portland cement is about 10 hours.
- The expansion of cement after heating and cooling the mould, should not exceed 10mm.



Mechanical properties of cement

- The compressive strength at the end of 3 days should not be less than 11.5 N/mm^2 and that at the end of 7 days should not be less than 17.5 N/mm^2 .
- The tensile strength at the end of 3 days should not be less than 2 N/mm^2 and that at the end of 7 days should not be less than 2.50 N/mm^2 .

Chemical properties of cement

- The ratio of percentage of alumina to iron oxide should not be less than 0.66.
- The ratio of percentage of lime to alumina, iron oxide and silica, known as lime saturation factor (LSF) should not be less than 0.66 and should not be more than 1.02.
- Total loss on ignition should not be more than 4 percent.
- Total sulphur content should not be more than 2.75 percent.
- Weight of insoluble residue should not be more than 1.5 percent.
- Weight of magnesia should not exceed 5 percent.

Importance and application of blended cement with fly ash and blast furnace slag.

- Blended cement are produced by intergrinding portland cement clinker with other specified materials or by blending portland cement with the other materials, or a combination of intergrinding and blending. Binary blended cements contain two constituent materials, while ternary blended cements contain three constituent materials.
- Fly ash is a fine powder that is a byproduct of burning pulverized coal in electric generation power plants. Fly ash is a pozzolana, a substance containing aluminous and siliceous material that forms cement in the presence of water.
- When mixed with lime and water, fly ash forms a compound similar to Portland cement. This makes fly ash suitable as a prime material in blended cement.
- When used in concrete mixes, fly ash improves the strength and segregation of the concrete and makes it easier to pump.



- Blast furnace slag is a nonmetallic coproduct produced in the production of iron, iron ore, iron scrap, and fluxes. It consists primarily of silicates, aluminosilicates, and calcium-alumina-silicates.
- It reduces water demand and therefore water-cement ratio can be reduced.
- It improves workability for the same water content.
- The blended cements are finer as compared to OPC, therefore the permeability of concrete is less. This results into improved durability

Advantage:-

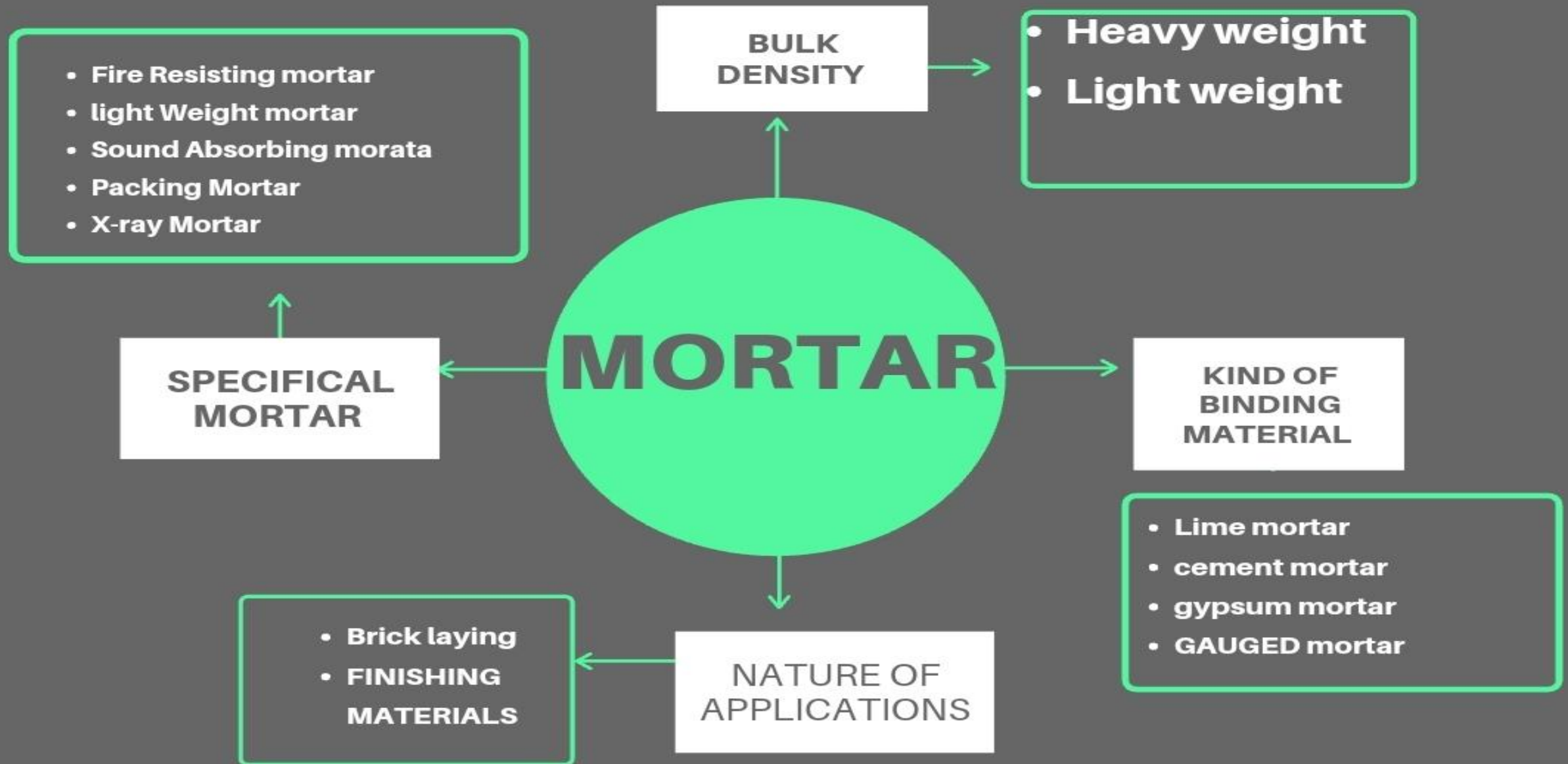
1. Energy saving
2. Pollution control
3. Conservation of Natural Resources. (Lime, silica, alumina)





MORTAR





MORTAR:-

- The term mortar is used to indicate a paste prepared by adding required quantity of water to a mixture of binding material like cement or Lime and fine aggregates like sand. The two components of mortar namely the binding material and fine aggregates are sometimes referred to as matrix.
- The durability, quality and strength of mortar will mainly depends on quantity and quality of the matrix. The combined effect of the two components of mortar is that the mass is able to bind the bricks or stones firmly.

Types of Mortar

- The mortar are classified on the bases of the following
 1. Bulk density
 2. Kinds of binding material
 3. Nature of application
 4. Special mortars
- **Bulk density:**
 - According to bulk density of mortar in dry state, the mortars are two types
 1. **Heavy mortars** bulk density is more than 1500kg/m^3 and prepared from heavy quartz.
 2. **Lightweight mortars** – bulk density is less than 1500kg/m^3 and prepared from light porous sands.



▪ **Kinds of binding Material**

- According to the kinds of binding material, several factors such as expected working conditions, hardening temperature, moisture conditions, etc should be considered. The mortars are classified into four categories.

1. **Lime Mortar** - in this mortar, lime is used as binding material. Lime may be fat lime or Hydraulic lime. Fat lime mortar 1:2 to 1:3 and hydraulic lime mortar may be 1:2 by volume.
2. **Cement mortar:** In this mortar, cement is used as binding material. Depending upon the strength required and importance of work, the proportion of cement to sand varies from 1:2 to 1:6 or more.
3. **Gauged Mortar or composite mortar:** The process of adding cement to lime mortar to improve the quality of lime mortar is known as gauging. It makes lime mortar economical, strong and dense. The usual proportion of cement to lime by volume is about 1:6 to 1:8.
4. **Surkhi Mortar:-** In case of fat lime as binding material sand is partly or fully replaced by Surkhi to form a mortar called surkhi Mortar. Use in All kind of foundation work and masonry work
5. **Gypsum mortar:** These mortars are prepared from gypsum binding material such as building gypsum and anhydrite binding materials.

Nature of Application:

- According to the nature of application, the mortars are classified into two categories.

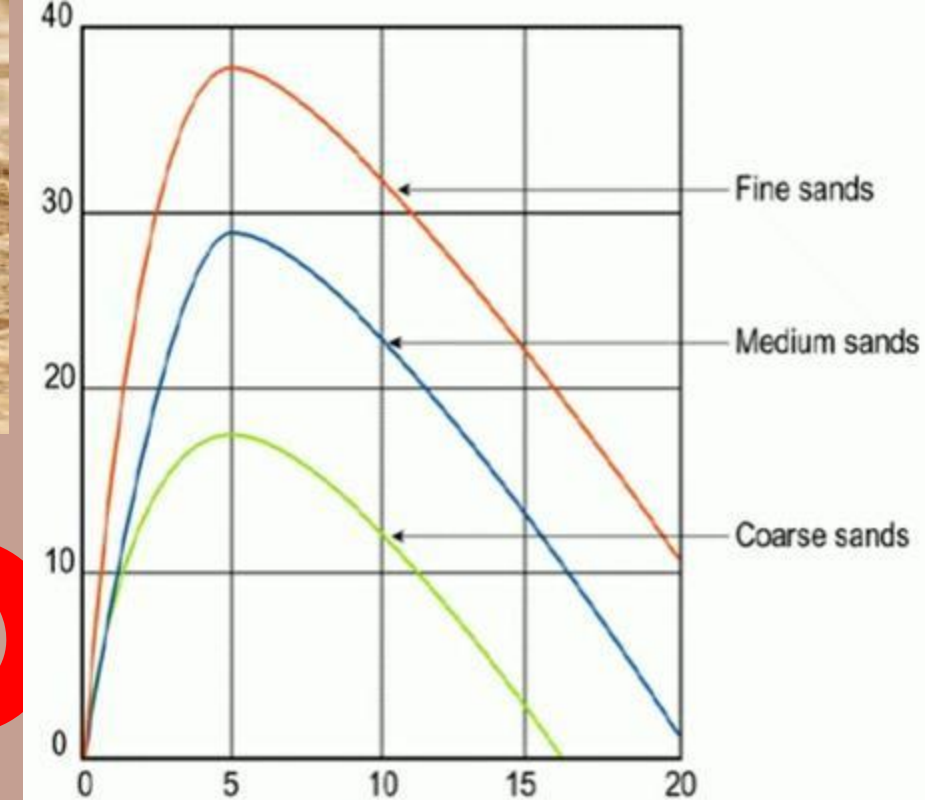
1. **Brick laying mortars:** Mortars for brick laying are intended to be used for brick works and walls. Depending upon the working conditions and type of construction, the composition of masonry mortars with respect to the kind of binding materials is decided.
2. **Finishing Mortars:** these mortars include common plastering work and mortars for developing architectural or ornamental effects. Generally cement or lime is used as binding material.



▪ **Special Mortars:**

- 1. Fire resistant mortar-** This mortar is prepared by adding aluminous cement to finely crushed powder in 1:2 ratio of aluminous cement with crushed powder of fire bricks used for fire brick lining furnaces, fire places, ovens etc.
- 2. Light weight mortar** – This mortar is prepared by adding sawdust, wood powder to lime or cement mortar for sound proof and heat proof construction.
- 3. Packing Mortar** – To pack of oil wells, special mortars possessing the properties of high homogeneity, water resistance, predetermined setting time, ability to form solid water proof plugs in cracks and voids of rocks, resistance to subsoil water pressure etc. have to be formed with cement sand, cement loam and cement sand loam mortars.
- 4. Sound absorbing mortars:** To reduce the noise level, sound absorbing mortars with Portland cement, lime, gypsum, slag Portland cement etc as the binding materials employed in its composition. The aggregates re selected from lightweight porous material such as pumice, cinders etc.
- 5. X-ray shielding mortar:** This type of mortar is used for providing the plastering coat to walls and celling of x-ray cabinets. This is heavy mortar with bulk density over 2200kg/m³ is used. The aggregates are obtained from heavy rock and suitable admixture are added to enhance protective property of such a mortar.





SAND



Sources of Sand:

Sand particles consist of small grains of silica (SiO_2). It is formed by the decomposition of sand stones due to various effects of weather.

The following are the natural sources of sand.

1. **Pit Sand:** This sand is found as ***deposits in soil*** and it is obtained by forming pits to a depth of about 1m ***to 2m from ground level***. Pit sand consists of sharp angular grains, which are free from salts for making mortar, clean pit sand free from organic and clay should only be used.
2. **River Sand:** River sand consists of fine rounded grains. Colour of river sand is almost white. As the river sand is usually available in clean condition, it is widely used for construction purposes.
3. **Sea Sand:** Sea sand consists of rounded grains in light brown colour. Sea sand consists of salts which attract the moisture from the atmosphere and causes dampness, efflorescence and disintegration of work.

Classification of sand

According to the size of grains, the sand is classified as fine, coarse and gravelly.

1. The sand passing through a screen with ***clear openings of 1.5875 mm is known as the fine sand***. It is mainly used for ***plastering***.
2. The sand passing through a screen with ***clear openings of 3.175 mm is known as the medium sand***. It is mainly used for ***masonry works***.
3. The sand passing through a screen with ***clear openings of 7.62 mm is known as the gravelly sand***. It is mainly used for ***concrete work***.



■ Bulking of Sand:-

The volume increase of fine aggregate due to presence of moisture content is known as bulking.

For a **moisture content of 5 to 8 percent, the increase in volume may be about 20 to 40 percent**, depending upon the grading of sand. The finer the material, the more will be the increase in volume for a given moisture content.

Bulking of aggregate is dependent upon two factors,

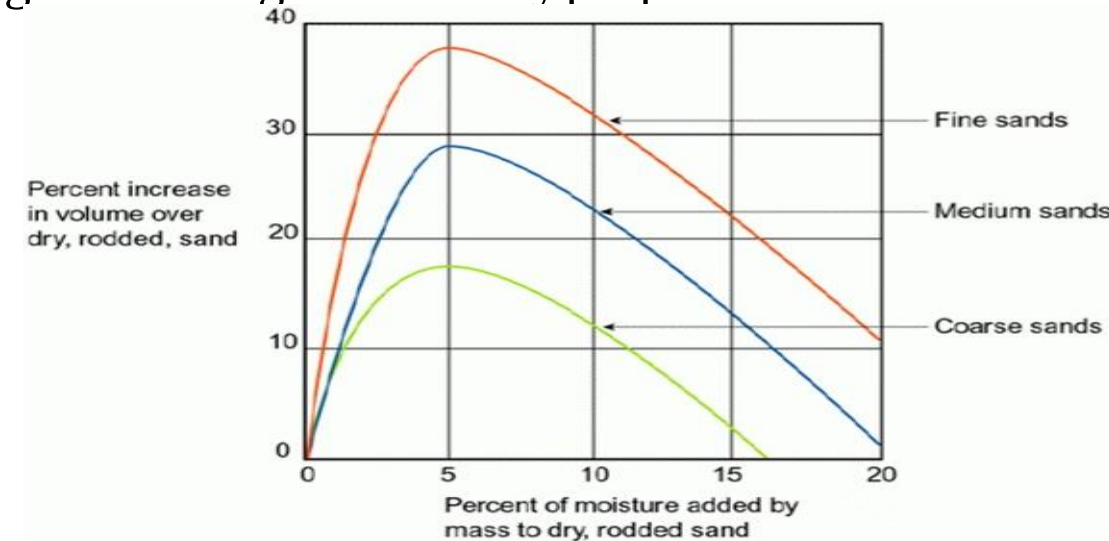
1. Percentage of moisture content

2. Particle size of fine aggregate

- Bulking increases with increase in moisture content upto a certain limit and beyond that the further increase in moisture content results in decrease in volume.
- When the fine aggregate is completely saturated it does not show any bulking.
- Fine sand bulks more as compared to coarse sand, i.e. percentage of bulking is indirectly proportional to the size of particle.

WHY TO DETERMINE PERCENTAGE OF BULKING?

- Due to bulking, fine aggregate shows completely unrealistic volume. Therefore, it is absolutely necessary that consideration must be given to the effect of bulking in proportioning the concrete by volume.
- If care is not given to the effect of bulking, in the case of volume batching, the resulting concrete is likely to be undersanded and harsh. It will also affect the yield of concrete for a given cement content.



Gravel as building material

An integral component of Concrete and outdoor design alike. It is used to build homes and highways as well as make Concrete.

Gravel can be both decorative and functional. It can be used as Mulch in a home garden or as a method of erosion control. Many industries use this material in their day-to-day functions.

Morrum

Morrum is used for construction material for building, raw material for construction of dam, raw material for road construction, paving etc. Morrum can be frequently used as sub-base materials. They are good material for building huts and paths, as they can be compacted easily to form hard surfaces.

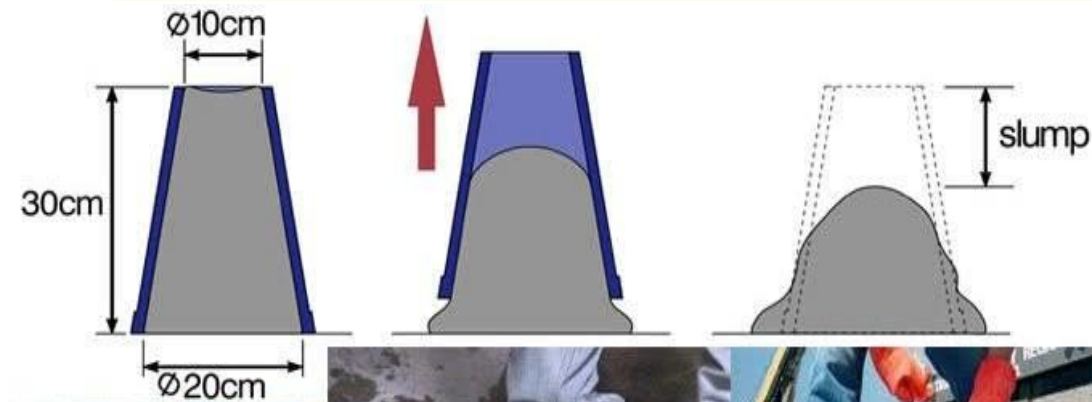
Fly Ash

- useful material in manufacturing bricks,
- stabilizing soil and to improve workability.
- One of the most common uses of fly ash is in Portland cement concrete pavement or PCC pavement. Road construction projects using PCC can use a great deal of concrete, and substituting fly ash provides significant economic benefits.
- Fly ash has also been used as embankment and mine fill.





CONCRETE



Definition:-

Concrete is the mixture of Binding material(cement or lime) with FINE AGGREGATE and Coarse Aggregate with required water cement ratio,to gain a hardened mass is known as concrete.

Concrete composition

The main constituents of concrete are

a. Cement / Lime:

- Main purpose of this material to bind the constituents added in concrete.

Before introduction of ordinary Portland cement, lime was used as cementing material. At present most of the cement concrete works in the building construction is done with ordinary Portland cement. But other special varieties of cement such as rapid hardening cement, high alumina cement are used under certain circumstances. The cement should comply with all standard specifications.

b. Fine Aggregates:

- Purpose of this material in concrete is to occupies most of the volume of the concrete. It is the stuff that the cement paste coats and binds together.
- The material, which is passed through 4.7625mm I.S.test sieve, is termed as fine aggregates. Usually natural river sand is used as fine aggregates. But places where natural sand is not available economically, finely crushed stone may be used as fine aggregates.



c. Coarse Aggregates:

- The composition, shape, and size of the aggregate all have significant impact on the workability, durability, strength, weight, and shrinkage of the concrete. Aggregate can also influence the appearance of the cast surface, which is an especially important consideration in precast concrete
- The material retained on 4.7625mm size B.S.test sieve is termed as coarse aggregates. Broken stone is generally used as coarse aggregates.
- For thin slabs, and walls, the maximum size of coarse aggregates should be limited to one third the thickness of the concrete section.

d. Water:

Water to be used in the concrete work should have the following properties.

- It should be free from oils.
- It should be free from acids or alkalies.
- It should be free from Iron, Vegetables matter or other substance, which is likely to have adverse effect on concrete.
- It should be fit for drinking purpose

Water cement ratio

The water in concrete has to perform the following two function

1. The water enters into chemical action with cement and this action causes the setting and hardening of concrete.
 2. The water lubricates the aggregates and it facilitates the passage of cement through voids of aggregate. Water makes the concrete workable.
- It is found theoretically that water requires for these two functions is about 0.5 to 0.6 times the weight of cement. This ratio of the amount of water to the amount of cement by weight is termed as the water cement ratio and the strength and quality of concrete primarily depends upon this ratio.

CLASSIFICATION OF CONCRETE

CONCRETE

Mixture of BM,FA,CA & Water

Based on
Binding material

- Cement
- Gypsum
- Lime
- Mud

BASED ON
STRENGTH

- Low strength
(M5- M20)
- Med.strength
(M25-M40)
- HIGH STRENGTH
(M40 above)

BASED ON
DENSITY

- Extra light
weight(<500kg/m³)
- Light weight (density
500-1000Kg/m³)
- Med. weight (1000-
2500 kg/m³)
- High density
(>2500kg/m³)

BASED ON
CASTING

- Pre Cast
- Cast in Situ

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Workability:-

- Workability of Concrete is a broad and subjective term describing how easily freshly mixed concrete can be mixed, placed, consolidated, and finished with minimal loss of homogeneity.

The important facts in connection with workability are as follows

- If more water is added to attain the required degree of workmanship, it results into concrete of low strength and poor durability.
- The workability of concrete is also affected mainly by water content, water cement ratio and aggregate cement ratio.
- It is also affected by the grading, shape, texture and maximum size of the coarse aggregate to be used in the mixture.
- Test for Workability
 1. SLUMP TEST :- widely used in field with slump cone size (100mm dia at Top, 200mm dia at bottom surface and 300mm high)
 2. COMPACTING FACTOR TEST :- widely used laboratory test and used for low workable concrete.
 3. Flow table test
 4. Vee bee Consistency

Mechanical properties

Performance of concrete is evaluated from mechanical properties which include shrinkage and creep, compressive strength, tensile strength, flexural strength, and modulus of elasticity. But compressive strength of concrete is the most important characteristic and it is generally assumed that an improvement in concrete compressive strength will improve its mechanical properties.

Compressive strength

Characteristic strength of concrete is the strength of concrete specimens casted and tested as per given code of practice and cured for a period of 28 days; 95% of tested cubes should not have a value less than this value. The compressive strength of concrete is calculated by applying load in cube of size 150 mm and dividing the maximum applied load with the cube area.



Grading of aggregates

- In order to obtain concrete of denser quality, the fine and coarse aggregates are properly graded. The grading of fine aggregates is expressed in terms of BIS test sieve nos. 480, 240, 120, 60, 30 and 15.
- The grading of fine aggregates has a marked effect on the uniformity, workability and finishing qualities of concrete.
- The grading of coarse aggregates may be varied through wider limits than those of sand without appreciable effect on the work ability of concrete.

Mixing

The process of rolling, folding and spreading of particles is known as the mixing of concrete. There are two types of concrete mixing

1. Hand mixing
2. Machine mixing

1. Hand Mixing:

For hand mixing, the materials are stacked on a water tight platform, which may be either of wood, brick or steel. The materials should be thoroughly mixed, at least three times, in dry condition before water is added. The prepared mix should be consumed in 30 minutes after adding water. The mixing by hand is allowed in case of small works or unimportant works where small quantity of concrete is required. It is advised to add **10% extra cement** to guard against the possibility of inadequate mixing by this method.

2. Machine mixing:

For machine mixing, all the materials of concrete including water, are collected in a revolving drum and then the drum is rotated for a certain period. The resulting mix is then taken out of the drum

Placing:-

Concrete is placed on form works. The form works should be cleaned and properly oiled. If concrete is to be placed for foundation, the soil bed should be compacted well and is made free from loose soil. Concrete should be dropped on its final position as closely as possible. If it is dropped from a height, the coarse aggregates fall early and then mortar matrix. This segregation results into weaker concrete.



Compacting

In the process of placing concrete, air is entrapped. The entrapped air reduces the strength of concrete up to 30%. Hence it is necessary to remove this entrapped air. This is achieved by compacting the concrete after placing it in its final position. Compaction can be carried out either by hand or with the help of vibrators.

a. Hand Compaction:

In this method concrete is compacted by ramming, tamping, spading or by slicing with tools. In intricate portions a pointed steel rod of 16 mm diameter and about a metre long is used for poking the concrete.

b. Compaction by Vibrators:

Concrete can be compacted by using high frequency vibrators. Vibration reduces the friction between the particles and set the motion of particles. As a result entrapped air is removed and the concrete is compacted. The use of vibrators reduces the compaction time. When vibrators are used for compaction, water cement ratio can be less, which also help in improving the strength of concrete. Vibration should be stopped as soon as cement paste is seen on the surface of concrete. Over vibration is not good for the concrete.

The following types of vibrators are commonly used in concreting:

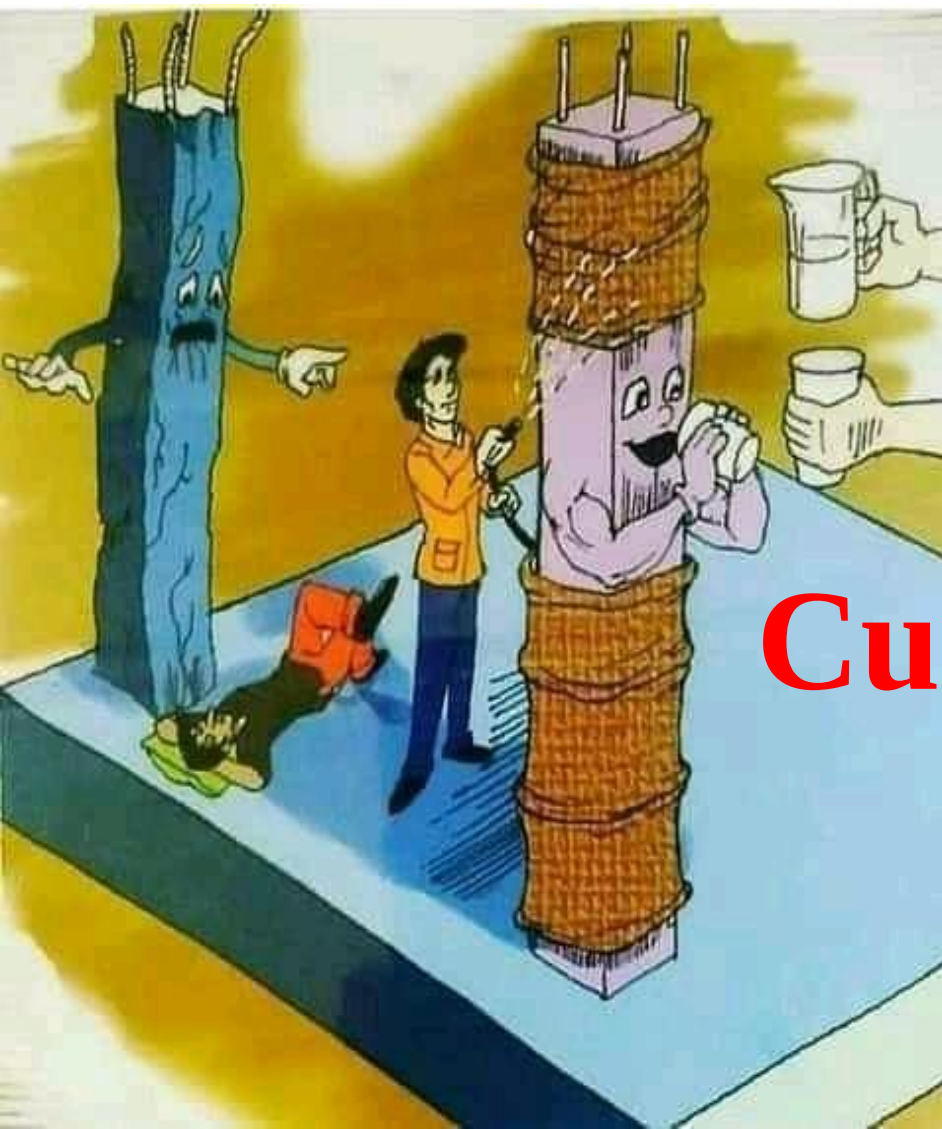
- i. Needle or immersion vibrators
- ii. Surface vibrators
- iii. Form or shutter vibrators
- iv. Vibrating tables.

Needle vibrators are used in concreting beams and ***columns***.

Surface vibrators and form vibrators are useful in ***concreting slabs***.

Vibrating tables are useful in preparing ***precast concrete elements***





Curing of Concrete

Curing of concrete

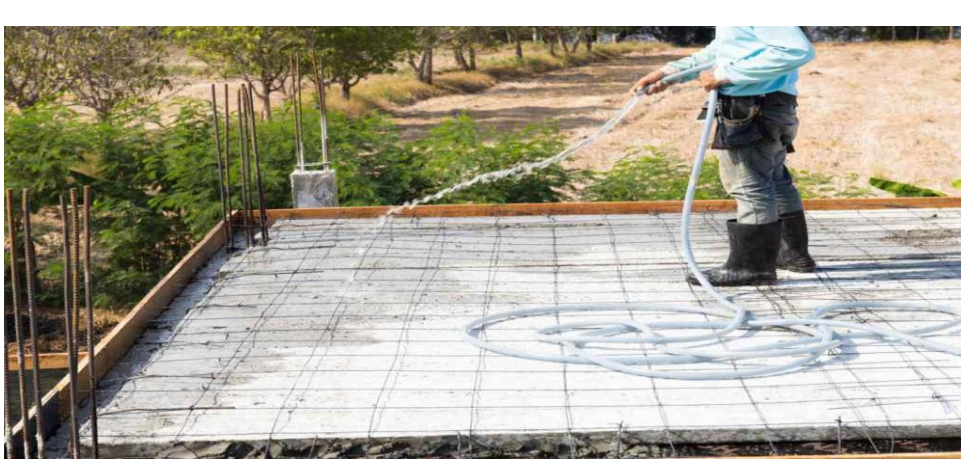
- Curing may be defined as the process of maintaining satisfactory moisture and temperature conditions for freshly placed concrete for some specified time for proper hardening of concrete. Curing in the early ages of concrete is more important. Curing for 14 days is very important. Better to continue it for 7 to 14 days more. If curing is not done properly, the strength of concrete reduces. Cracks develop due to shrinkage. The durability of concrete structure reduces.

The following curing methods are employed:

- a. Spraying of water
- b. Covering the surface with wet gunny bags, straw etc.
- c. Ponding
- d. Steam curing and
- e. Application of curing compounds.

a. Spraying of water: Walls, columns, plastered surfaces are cured by sprinkling water.

b. Wet covering the surface: Columns and other vertical surfaces may be cured by covering the surfaces with wet gunny bags or straw.



c. Ponding:

The horizontal surfaces like slab and floors are cured by stagnating the water to a height of 25 to 50 mm by providing temporary small hunds with mortar.

d. Steam curing:

In the manufacture of pre-fabricated concrete units steam is passed over the units kept in closed chambers. It accelerates curing process, resulting into the reduction of curing period.

e. Application of curing compounds:

Compounds like calcium chloride may be applied on the curing surface. The compound shows affinity to the moisture and retains it on the surface. It keeps the concrete surface





CHAPTER 4 (BUILDING MATERIAL)

OTHER CONSTRUCTION MATERIALS



Cement

Cement is a material that sets, hardens and can bind together all other building materials.

Sand

Sand is extracted from river bed and is sieved fine. It is then used in preparing concrete mixture.

Stone(Gitti)

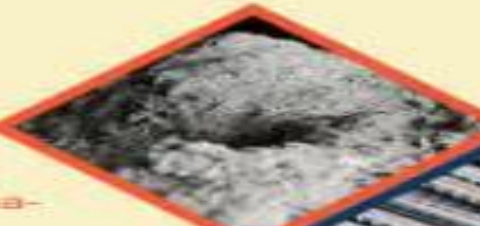
Stones (Gitti) are the fillers in concrete mixes. It is offered in 6mm, 12 mm, 20 mm and 40 mm sizes in India.

Wall Putty

Wall Putty is a White Cement based fine powder which provides an ideal finishing for concrete / cement plastered walls and ceilings.

Paint

Paint is used to protect, color, or provide texture to walls and other objects.



TMT Bars

Thermo-Mechanical Treatment is a process to produce high strength steel bars from low carbon steel. They are used to give solid structure.

Binding Wires

Binding wires are used to bind the TMT Steel Bars and help in providing proper structure to the construction due to the stability of the TMT Steel Bars.

Brick

Bricks are used for building walls. They come in different shapes, sizes and strength based on different construction requirements.

Cement Block

High strength cement blocks are mainly used for load bearing walls as they have the capacity to withstand the pressure due to the load.

CHAPTER 4 :- Other Construction Materials

4.1 Timber: Classification and Structure of timber.

4.2 Seasoning of timber – Importance. Characteristics of good timber.

4.3 Clay products and refractory materials – Definition and Classification.

4.4 Properties and uses of refractory materials- tiles, terracotta, porcelain glazing.

4.5 Iron and Steel: Uses of cast iron, wrought iron, mild steel and tor steel

Classification of Timber

Parts of tree

1. Trunk
2. Crown
3. Roots

The following are the important basis for classification;

- (i) Mode of growth
- (ii) Modulus of elasticity
- (iii) Durability
- (iv) Grading
- (v) Availability.

Classification Based on Mode of Growth

On the basis of mode of growth trees are classified as;

- (a) Exogenous and (b) Endogenous

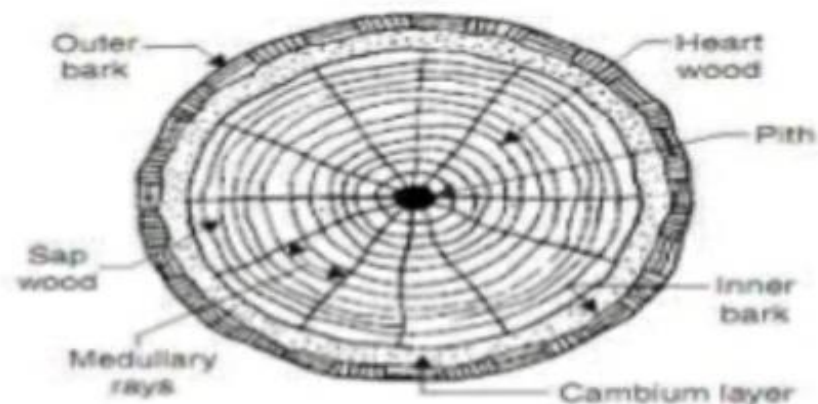
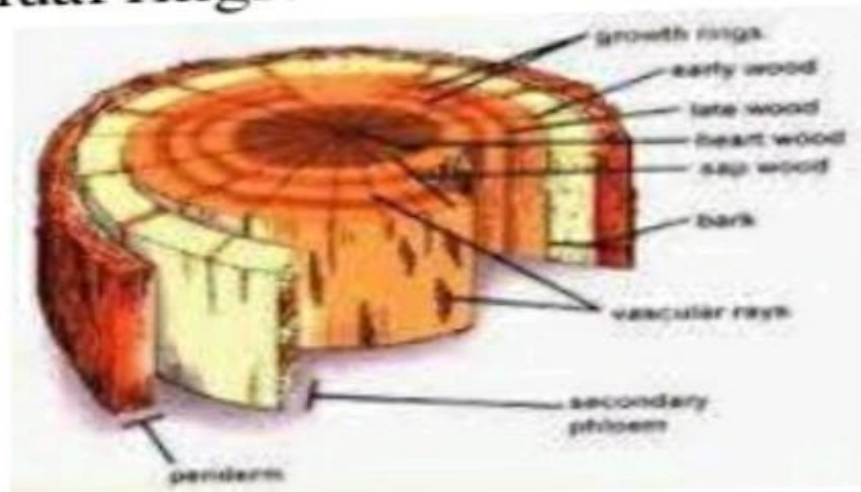
Exogeneous

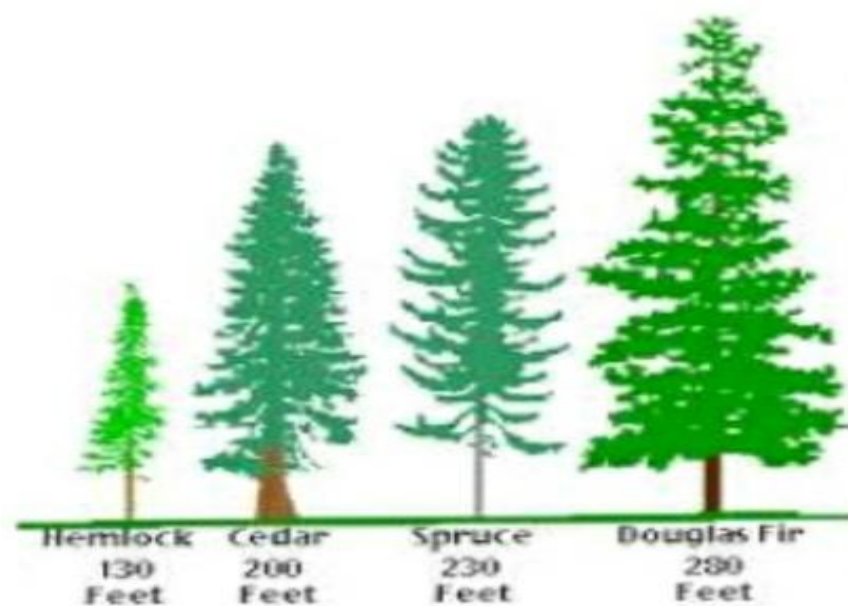
These trees grow outward by adding distinct consecutive ring every year. These rings are known as annual rings. Hence it is possible to find the age of timber by counting these annual rings.

These trees may be further divided into (1) coniferous and (2) deciduous.

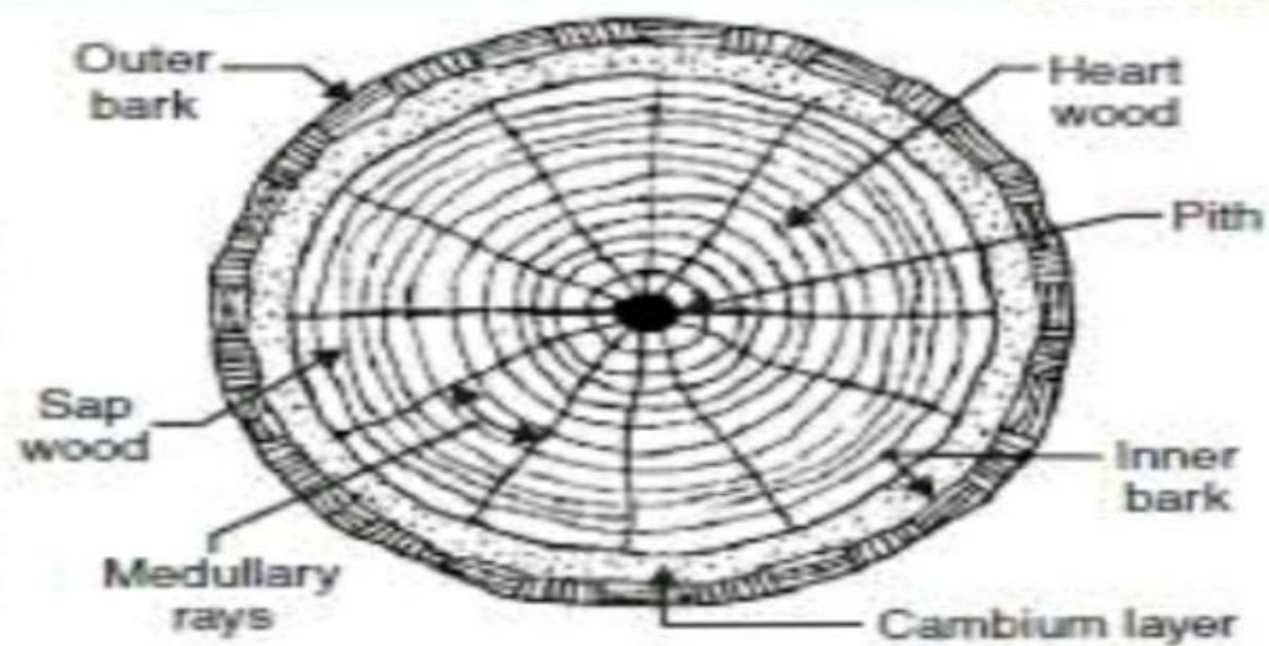
Coniferous trees are having cone shaped leaves and fruits. The leaves do not fall till new ones are grown. They yield soft wood.

Deciduous trees are having broad leaves. These leaves fall in autumn and new ones appear in springs. They yield strong wood and hence they are commonly used in building construction.





Coniferous trees



Cross-section of exogeneous tree





Neem tree



Banyan tree



Babool tree

Deciduous trees



Endogenous

These trees grow inwards. Fresh fibrous mass is in the inner most portion. Examples of endogenous trees are bamboo and cane. They are not useful for structural works.



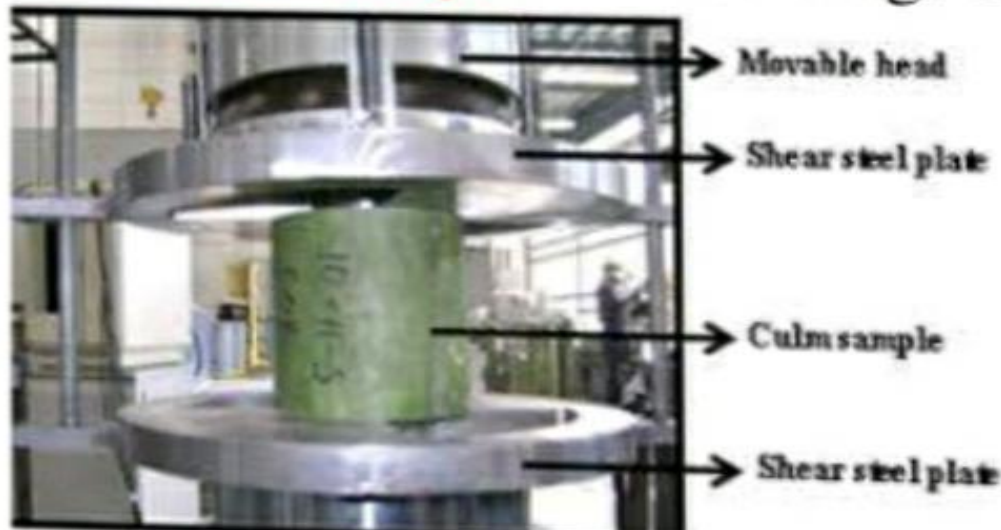
Applications



Classification Based on Durability

Durability tests are conducted by the forest research establishment. They bury test specimen of size $600 \times 50 \times 50$ mm in the ground to half their length and observe their conditions regularly over several years. Then timbers are classified as;

- High durability:** If average life is more than 10 years.
Moderate durability: Average life between 5 to 10 years.
Low durability: Average life less than 5 years.



Classification Based on Grading

IS 883-1970 classifies the structural timber into three grades-select grade, grade I and grade II. The classification is based on permissible stresses, defects etc.

Various defects which are likely to occur in timber may be grouped into the following three:

- (i) Due to natural forces
- (ii) Due to defective seasoning and conversions.
- (iii) Due to attack by fungi and insects.

(i) Defects due to Natural Forces

- a) Knots
- b) Shakes
- c) Wind cracks
- d) Upsets

Classification Based on Availability

Forest departments classify timbers based on the availability as;

X—Most common. 1415 m³ or more per year

Y—Common. 355 m³ to 1415 m³ per year

Z—Less common. Less than 355 m³ per year.

Classification Based on Modulus of Elasticity

Young's modulus is determined by conducting bending test. On this basis timber is classified as;

Group A: $E = 12.5 \text{ kN/mm}^2$

Group B: $E = 9.8 \text{ kN/mm}^2 \text{ to } 12.5 \text{ kN/mm}^2$

Group C: $E = 5.6 \text{ kN/mm}^2 \text{ to } 9.8 \text{ kN/mm}^2$.



Structure.

On examining the cross section of the trunk of an exogenous tree.

Structure of timber

From the visibility aspect, the structure of a tree can be divided into two categories

- 1. Macro structure
- 2. Micro structure

I. **Macro structure:** The structure of wood visible to the naked eye or at a small magnification is called macro structure.

Pith or medulla.

It is the first formed portion of the stem of tree. It consists entirely of cellular tissues. The pith, which when the plant is young, contains a large amount of fluid and nourishes the plant. It dies up and decays when the plant becomes old. Sap is then transmitted by the woody fibres that deposit about the pith. Pith of branches is a mere prolongation of the pith of stem.

Annual rings.

The rings of woody fibre arranged in concentric circle around the pith are known as annual rings because one such ring is added every year.

Heart wood.

Innermost rings surrounding the pith constitute the heart wood. This wood is darker in colour, stronger, more compact and durable.

Sap wood.

Outer annual rings of the tree constitute the sap wood which transmits the sap from roots to branches. Compared with heart wood, sap wood is lighter in colour, weaker and more liable to decay.

Cambium layer.

Outermost one ring between the bark and sap wood which is not yet converted into wood is known as the cambium layer. In due course, cambium layer changes to sapwood. If the cambium layer is exposed by removing the bark, the cells cease to be active and results in death of tree.

Medullary rays.

These are thin horizontal veins radiating from the pith towards the bark. They carry sap from outside to the inner parts of tree and nourish it. They keep the annual rings tightly gripped together. In some trees they might be found broken or may not even be clearly visible.

Bark.

It is outermost protective covering of cells and woody fibres on a tree. In course of time older layer split and scale off.

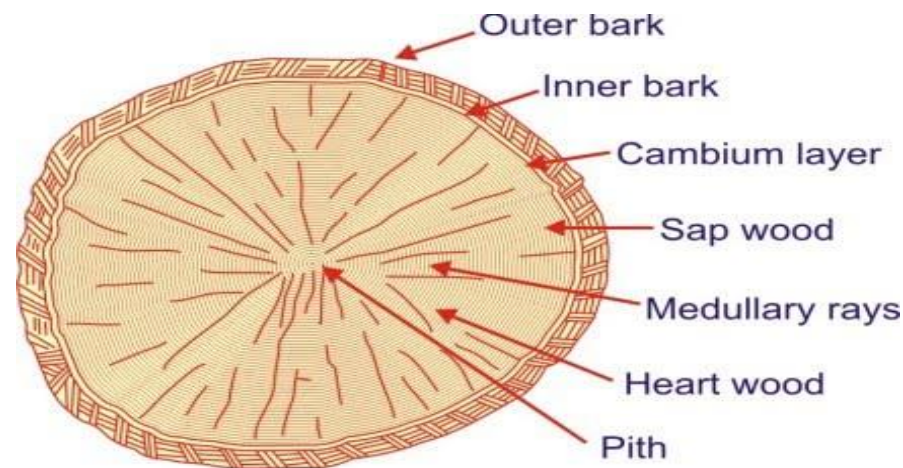


FIG. 9.1. Structure of Exogenous tree.

- **II Micro structure:** The structure of wood apparent only at great magnifications is called micro structure under micro scope, it becomes evident that the wood consists of living and dead cells of various sizes and shapes.

4.2 Seasoning of timber – Importance.

- Seasoning of timber is the process of drying timber or removing moisture or sap, present in a freshly felled timber, under more or less control condition.
- Freshly felled timber contains a large quantity of moisture roughly from 100 to 200 % , based on dry weight of wood.
- A *well seasoned piece of wood* may contain about **10 to 12 % moisture** and will be in equilibrium with atmospheric humidity of a particular place.

The **importance of seasoning of timber** is

- To check/minimise the tendency of timber to shrink, warp and split.
- To increase strength, durability and electrical resisting power of the timber.
- To make timber safe from attack of fungi and insect.
- To reduce the weight of transport purposes, handling and there by reduction in cost.
- To make timber fit for receiving treatment of paints, preservatives, varnishes etc.
- To make timber suitable for gluing.
- To make timber easily workable and to facilitate operations during conversion.

Methods of seasoning of timber

Seasoning of timber may be carried out in two ways

1. Natural seasoning
2. Artificial seasoning

1. Natural seasoning

It may be air seasoning or water seasoning. Air seasoning is carried out in a shed with a platform. On about 300 mm high platform timber bunks are stacked as shown in Fig.

Water Seasoning

Water seasoning is the process in which timber is immersed in water flow which helps to remove the sap present in the timber. It will take 2 to 4 weeks of time and after that the timber is allowed to dry. Well-seasoned timber is ready to use.

Air Seasoning

In the process of air seasoning timber logs are arranged in layers in a shed. The arrangement is done by maintaining some gap with the ground. So, platform is built on ground at 300mm height from ground. The logs are arranged in such a way that air is circulated freely between logs. By the movement of air, the moisture content in timber slowly reduces and seasoning occurs. Even though it is a slow process it will produce well-seasoned timber.

- A good timber should not contain more than 15% of moisture content.

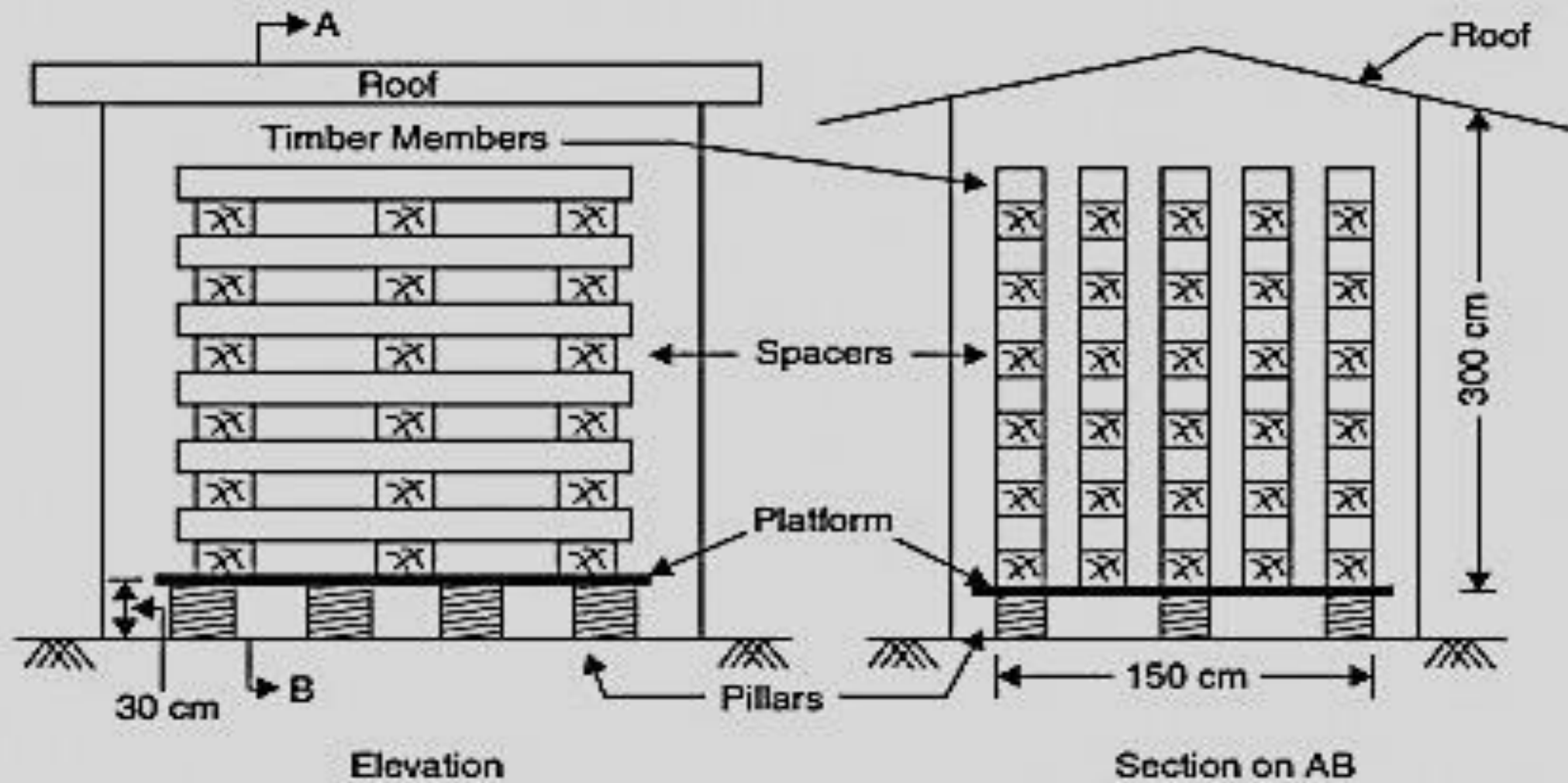


Fig. 1.8. Air seasoning

Artificial Seasoning:-

Natural seasoning gives good results but takes more time. So, artificial seasoning of timber is developed nowadays. By artificial seasoning, timber is seasoned within 4-5 days. Here also different methods of artificial seasoning are there and they are as follows.

Seasoning by Boiling

Chemical seasoning

Kiln seasoning

Electrical seasoning

Seasoning by Boiling

Seasoning of timber is also achieved by boiling it in water for 3 to 4 hours. After boiling timber is allowed to dry. For large quantity of timber boiling is difficult so, sometimes hot steam is passed through timber logs in an enclosed room. It also gives good results. The boiling or steaming process develops the strength and elasticity of timber but economically it is of heavier cost.

Chemical Seasoning

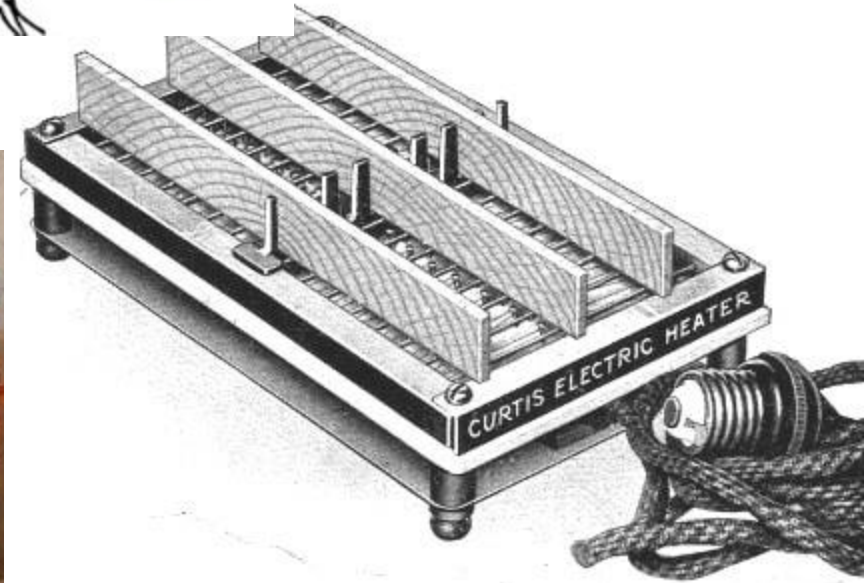
In case of chemical seasoning, timber is stored in a suitable salt solution for some time. The salt solution used has the tendency to absorb water from the timber. So, the moisture content is removed and then timber is allowed to dry. It affects the strength of the timber.

Kiln Seasoning

In this method timber is subjected to hot air in an air-tight chamber. The hot air circulates in between the timber logs and reduces the moisture content. The temperature inside the chamber is raised with the help of heating coils. When the required temperature is obtained, moisture content and relative humidity get reduced and timber gets seasoned. Even though it is a costly process, it will give good results strength-wise.

Electrical Seasoning

In the method of electrical seasoning, timber is subjected to high frequency alternating currents. The resistance of timber against electricity is measured at every interval of time. When the required resistance is reached, the seasoning process is stopped because resistance of timber increases by reducing moisture content in it. It is also called as rapid seasoning and it is uneconomical.



4.3 Characteristics of good timber.

The principal characteristics of timber of concern are strength, durability and finished appearance.

- Narrow annual rings, closer the rings greater is the strength.
- Compact medullary rays.
- Dark colour.
- Uniform texture.
- Sweet smell and a shining fresh cut surface.
- When struck sonorous sound is produced.
- Free from the defects in timber.
- Heavy weight.
- No woolliness at fresh cut surface.
- It should have regular annular ring etc.



4.3 Clay products and refractory materials – Definition and Classification.

- Clay products are one of the most important classes of structural materials.
- The raw materials used in their manufacture are clay blended with quartz, sand, chamatte (refractory clay burned at 1000–1400°C and crushed), slag, sawdust and pulverized coal.
- Structural clay products or building ceramics are basically fabricated by moulding, drying and burning a clay mass. Higher the bulk specific gravity, the stronger is the clay product.
- According to the method of manufacture and structure, bricks, tiles, pipes, terracotta, earthenwares, stonewares, porcelain, and majolica are well recognized and employed in building construction.
- **REFRACTORIES**
- These materials are capable of withstanding high temperature in different industrial processes.
- In addition to the thermal endurance, a refractory should be able to resist the chemical action of the material being heated and withstand the mechanical load.
- They have high dimensional and chemical stability and do not lose their physical shape and chemical composition. Refractories confine the heat and prevent the heat loss to the atmosphere from the outside walls of furnaces.



REFRACTORY MATERIAL



Classification:-

On the Basis of Chemical Behaviour

- **Acid refractories:** Combine readily with bases. Their chief constituent is silica: quartz, sand, ganister and silica bricks.
- **Basic refractories:** Consist mainly of basic oxides: magnesite and dolomite.
- **Neutral refractories:** Consist of materials which do not combine with either basic or acidic oxides: silicon carbide, chromite and carbon.

On the basis of resistance to temperature

- **Low quality** used in the manufacture of fire-bricks, as lining material for furnaces. The melting point of such materials is more than 1580 °C.
- **High quality** stable even at high temperature and they are used in the construction of modern aeroplanes such as jets, rockets etc. These materials are composed of either pure clay or metals or combination of clay and metals.

4.4 Properties and uses of refractory materials- tiles, terracotta, porcelain glazing.

1. TILES

Tiles are thin slabs of low melting clays used for various purposes in engineering constructions. These give a very pleasing appearance and good service properties. Roofing tiles, flooring tiles, wall tiles and partition tiles are some of the examples.

Following are the characteristics of a good tile:

- It should be free from any cracks, flaws or bends.
- It should be regular in shape and size.
- It should be sound, hard and durable.
- It should be well burnt.
- It should give a clear ringing sound when struck with hand or with one another or with light hammer.
- It should fit in properly, when placed in position.
- It should give an even and compact structure when seen on its broken surface.
- It should possess uniform colour.
- Tiles are widely used for flooring in kitchen, bathrooms, parking lots, rooftops and also used as tabletops for dining rooms, old factory floors, garages, gyms and sports complexes, schools and shops etc.



2. TERRACOTTA

The terra means earth and cotta means baked. Hence the terra-cotta means the baked earth. It is thus a type of earthenware or porous pottery made from local clays and glazed with glazes containing galena. It is soft enough to be scratched by a knife.

Following are the properties of terra-cotta:

- It is strong and durable material.
- It is available in different colours.
- It is cheaper than ordinary finely dressed stones.
- It is easily cleaned.
- It is easily moulded in desired shapes.
- It is fire-proof and can therefore be conveniently used with R.C.C. work.
- It is light in weight.
- It is not affected by atmospheric agencies and acids and is capable of withstanding weathering actions better than most kinds of stone.
- It is twisted due to unequal shrinkage in drying and burning.



PORCELAIN

- The term porcelain is used to indicate fine earthenware which is white, thin and semi-transparent. Since the colour of porcelain is white, it is also referred to as the whiteware.
- The clay of sufficient purity and possessing high degree of tenacity and plasticity is used in preparing porcelains. It is hard, brittle and non-porous. It is prepared from clay, felspar, quartz and minerals. The constituents are finely ground and then they are thoroughly mixed in liquid state. The mixture is given the desired shape and it is burnt at high temperature.
- The various types of porcelains are available and they are adopted for various uses such as sanitarywares, electric insulators, storage vessels, reactor chambers, crucibles, etc.
- The porcelains are of two types, namely low voltage porcelain and high voltage porcelain.
 - The low voltage porcelain is prepared by dry process and it is mainly used for switch block, insulating tubes, lamp sockets, etc.
 - If some quantity of alumina or silicate of magnesia is added, it can resist high temperature to a certain extent.

GLAZING

- It is the process of forming some transparent film over the surfaces of bricks, tiles, earthenware or stoneware to improve upon their appearance and also to protect them from the action of weather, sewage, chemicals or other destroying agents.
- A glaze is a glassy coat of thickness about 0.1 to 0.2 mm applied on the surface of an item and then fused into place by burning at high temperature.
- Glazing should be such that it does not craze when the article is exposed to any change of temperature.
- Glazing may be transparent like glass or opaque like enamels. For obtaining coloured glazes, the oxides and salts of various metals or special refractory colouring agents are added.



- **Transparent Glazing**

Transparent glazing is of two types

1. Salt glazing
2. Lead glazing.

- 1. Salt glazing**

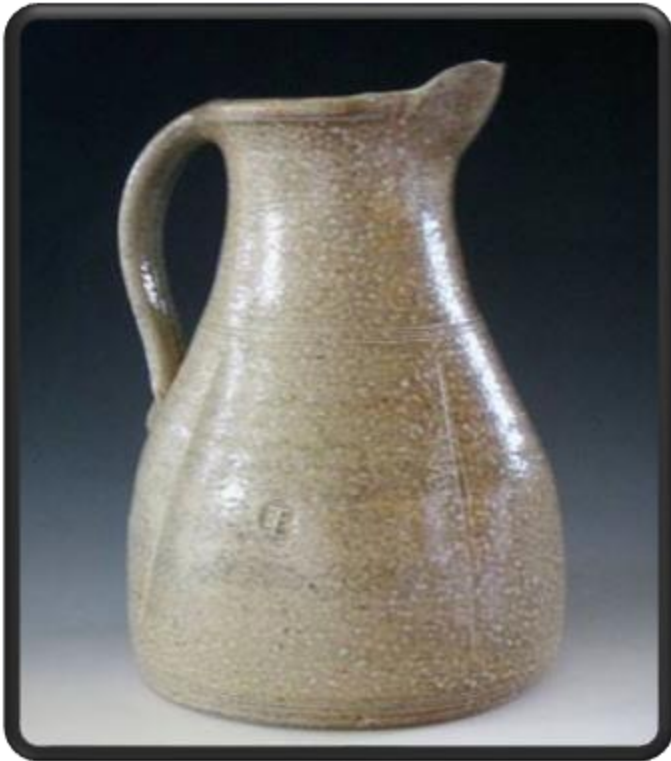
- In this method, common salt (sodium chloride) is thrown into the kiln, containing the articles to be glazed at the close of the burning operation when the temperature reaches to about 1300 °C.
- The salt vapourizes and attaches itself chemically to all exposed surfaces of the clay products, thus forming a thin layer of transparent glass over the surfaces. The quantity of salt and throwing at proper time should be done with extreme care.
- This method is useful for sanitary pipes and chemical stonewares.

- 2. Lead glazing**

- Lead glazing is preferred to salt glazing for getting articles of better quality.
- In this method, hot article to be glazed is dipped in a bath containing oxide of lead and tin when particles of these materials adhere to the article dipped. The article is then withdrawn and reburnt when high temperature of the furnace melts it forming a film of glass over the exposed surface.
- In this method of glazing, the glaze does not penetrate into the body of the ware and as a matter of fact, it can be easily detached from the surface of the ware.
- Uses: This method is used for terracotta, earthenwares and fire-clay wares.

Opaque Glazing or Slip Glazing

- The glazing materials consist of quartz, felspar, boric oxides, oxide of tin, zinc, lead, china clay etc. A mixture of these materials is prepared and ground to fine paste (known as slip) in the presence of water.
- The clay product to be glazed is first dried and dipped into the slip (paste) and then fired into the furnace at a temperature of about 120°C. During the process of firing the composition of glaze gets completely vitrified and forms uniform glaze of desired colour over the surface of the burnt clay product.
- In this glazing process, burning and glazing of the clay products are simultaneously achieved
- Uses: Opaque glazing is used where it is desired to give the whole or any part of the article a better appearance than that presented by the burnt material. Basins, dishes, cups, etc., are opaque glazed.



4.5 Iron and Steel: Uses of cast iron, wrought iron, mild steel and tor steel

PIG-IRON

- The crude impure iron which is extracted from iron ores is known as the pig-iron and it forms the basic material for the manufacture of cast-iron, wrought-iron and steel.

CAST-IRON

The cast-iron is manufactured by re-melting pig-iron with coke and limestone.

This re-melting is done in a furnace known as the cupola furnace.

Cast iron is a group of **iron**-carbon alloys with a **carbon content more than 2%**. Its usefulness derives from its relatively low melting temperature

Following are the important uses of cast-iron:

- For making cisterns, water pipes, gas pipes and sewers, manhole covers and sanitary fittings.
- For making ornamental castings such as brackets, gates, lamp posts, spiral staircases, etc.
- For making parts of machinery which are not subject to heavy shocks.
- For manufacturing compression members like columns in buildings, bases of columns, etc.
- For preparing agricultural implements.
- For preparing rail chairs, carriage wheels, etc.

- **Wrought iron**

The wrought-iron is almost pure iron and it hardly contains carbon more than 0.15 per cent or so. But the process of its manufacture is laborious and tedious.

- wrought iron is useful to make steel and cast iron. It is ductile, tough, malleable and strong under tensile loads.
- However, it cannot withstand sudden and excessive shocks.
- The presence of carbon, which accounts for its resistance to corrosion.
- A fracture surface of wrought iron reveals a fibrous structure.

USES:-

- it suitable for outdoor applications like gates, structural applications, railings, etc.
- The wrought-iron, at present, is used for rivets, chains, ornamental iron work, railway couplings, water and steam pipes, raw material for manufacturing steel, bolts and nuts, horse shoe bars, handrails, straps for timber roof trusses, boiler tubes, roofing sheets, armatures, electro-magnets, etc

- **MILD STEEL**

- Mild steel is a type of carbon steel with a low amount of carbon – it is actually also known as “low carbon steel.” Although ranges vary depending on the source, the amount of carbon typically found in mild steel is 0.05% to 0.25% by weight, whereas higher carbon steels are typically described as having a carbon content from 0.30% to 2.0%.
- Here are some examples of where it is used in the world:
 - Structural steel
 - Signs
 - Automobiles
 - Furniture
 - Decorations
 - Wire
 - Fencing
 - Nails

TOR STEEL

- TOR stands for Toriseg Steel Corporation of Luxembourg. It refers to a brand name.
- TOR steel specialized term is a cold twisted deformed steel reinforcement bar. Steel bars have surface deformation formed by twisting the steel after lengthening. This imparts high yield strength to steel and furnishes legitimate proper bondage with concrete.
- During the time period seventies to nineties, TOR steel was used for reinforcement purposes of the construction massively.
- It was better high-adherence steel at that time and had more tensile stress than anything else.
- The tor steels are used as lugs and ribs and to limit slippage.
- The most generally utilized bars for RCC work are the CTD bars.

	Cast Iron	Wrought Iron
DEFINITION	Cast iron is an alloy of iron which contains about 2-4% carbon by weight	Wrought iron is an alloy of iron which contains 0.02% carbon by weight
CARBON CONTENT	High	Very low
PRODUCTION OF ITEMS	Moulding	Working (by hammer)
PROPERTIES	Brittle, castable and strong	Ductile, workable and has a high tensile strength



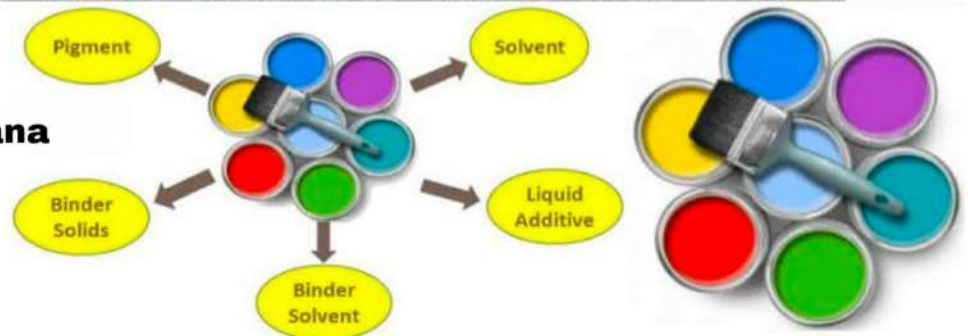
BUILDING MATERIAL & CONSTRUCTION TECHNOLOGY

CHAPTER- 05

SURFACE PROTECTIVE MATERIALS



BY:-Shubhashree Maharana



5 Surface Protective Materials

5.1 Composition of Paints, enamels, varnishes.

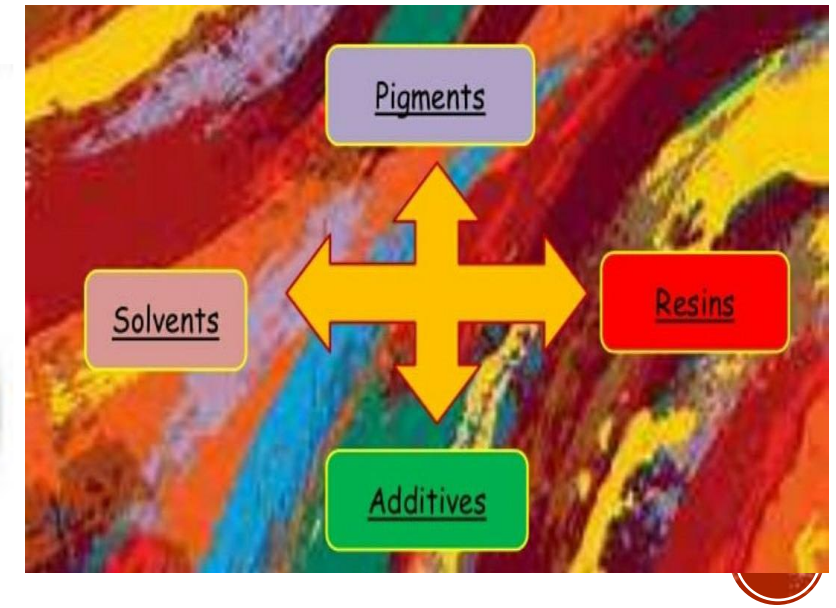
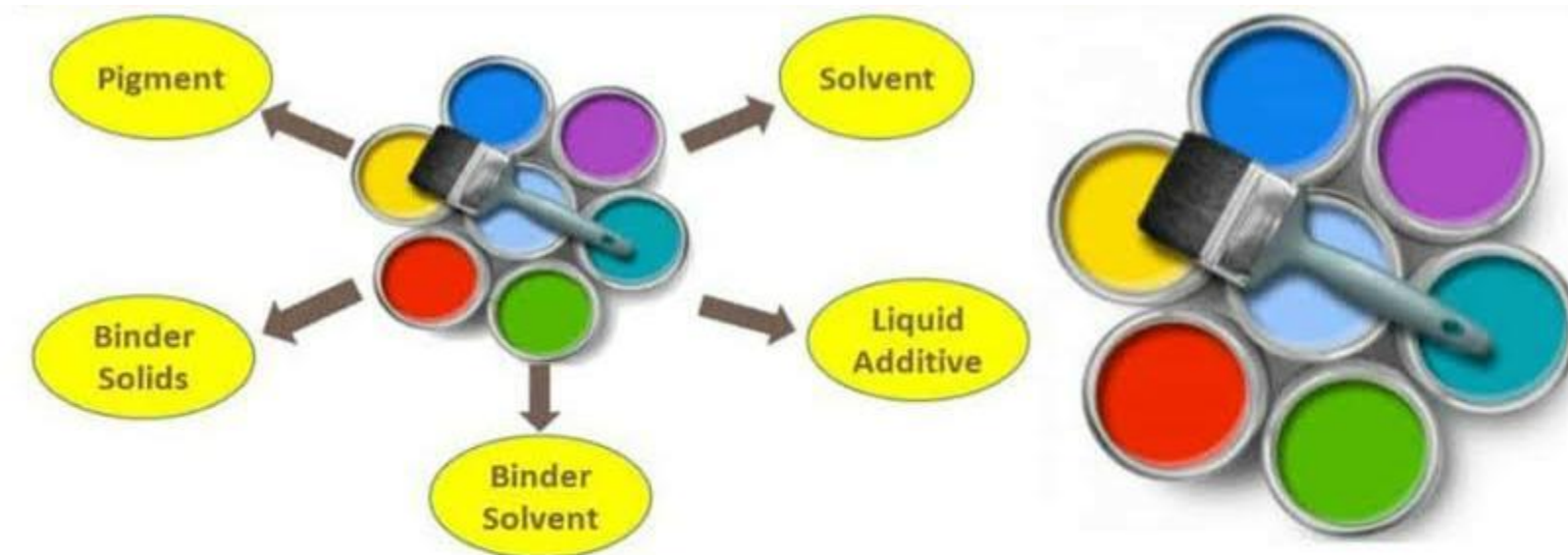
5.2 Types and uses of surface protective materials like Paints, Enamels, Varnishes, Distempers, Emulsion, French polish and Wax Polish.



5.1 Composition of Paints, enamels, varnishes.

PAINTS

- A wide variety of raw materials are used in the manufacture of paints but they can be grouped according to their function.
- Medium, vehicle or binder are terms used to refer to the oils or resins or combinations of the two that form the basis of all paints. Linseed oil is an example of a vegetable oil used as a binder.
- In all cases it must have the ability to change from a low viscosity liquid into a hard plastic film at the same time binding together the fine particles of pigment. The actual properties of the binder may be modified to a large extent by the pigment. Three main properties are required of the solid film:
 - a) It must have the correct gloss: All binders are glossy but have considerable variations.
 - b) It must adhere to the substrate (the surface being painted).
 - c) It needs the correct mechanical properties, this refers to the qualities of the combined film and substrate and include bending, scratching and impact.



Paint is made up of four main ingredients such as: Binder, Solvent, Pigment, and Additives

Binder:

Binders are polymers or resins which form a film on the substrate surface which helps in adhesion of the paint to substrate surface. It also keeps pigment particles together. Some famous binders that are used in paint, are:

- Alkyd Resins
- Acrylic Resins
- Latex
- Phenolic Resins
- Urethane Resins
- Epoxy Resins
- Chlorinated Rubber

Solvent:

Solvent is a medium in the paint which helps binders, pigment and additives to disperse in molecular form or in form of colloidal dispersions. Solvents or thinners are used to modify the viscosity of the paint to improve its workability. Once the solvent evaporates from the paint, it forms a solid coating. Some famous solvents that are used in paint, are:

- Water
- White Spirits
- Xylene
- Toluene
- Alcohols
- Ketones



BODY OF PAINT

S. No.	Name	Description
1.	Antimony white	This is nearly similar to the titanium white.
2.	Titanium white or titanium dioxide	It is an oxide of titanium of brilliant whiteness. It is a very fine pigment which is non-poisonous and unaffected by heat and acids. This base possesses high oil absorption, great elasticity and very high covering power (nearly twice the covering power of white lead). It is generally used as an under coat to enamel or organic coatings.
3.	White Lead	This is a carbonate of lead and it forms the base of lead paints. It possesses good bulk and is the most widely used base. It is not suitable for delicate work as lead becomes discoloured when exposed to the sulphur vapours. It is most suitable for wood surfaces and not used for iron surfaces as it does not afford protection against rusting.
4.	Red Lead	This base is an oxide of lead and it forms the base for lead paints. It has got excellent properties of rust prevention, toughness and durability. It is generally used for painting iron surfaces and as priming coat for wooden surfaces.
5.	Oxide of zinc or zinc white	This is an oxide of zinc and it forms the base of all zinc paints. It is smooth, transparent and non-poisonous. It is not discolored when exposed to the sulphur vapours. It has less bulk durable and it is difficult to work.
6.	Oxide of Iron	This is an oxide of iron, and it forms the base for all iron paints. The tints of paint obtained vary from yellowish brown to black. It is cheap, durable and protects the iron surfaces against rusting. It is used as priming coat for iron surfaces.
7.	Aluminium Powder	This forms the body of aluminium paints. It checks the cracking and warping defects of wood. It is generally used as a priming coat to new wood work.
8.	Lithopone	It is a white substance obtained by mixing equal quantities of zinc sulphide solution and barium sulphate solution in the full form of precipitate. It is cheap and has a good covering power. It is generally used for interior work as under coat. It is also used in cheap enamels.

Pigment:

- Pigment is a solid substance which gets dispersed throughout the coating to give it a colour, denseness to hide the substrate layer. Pigments are used to protect the substrate layer from harmful UV rays.
- Pigments are also used to increase gloss level of paint and to improve its durability and reduce ductility. Some famous Pigment that are used in paint are:
 - Titanium Oxide (TiO₂)
 - Zinc Oxide (ZnO)
 - Zinc Yellow
 - Yellow Dyes
 - Benzidine Yellows
 - Chrome Oxide Green

Additives:

- Additives are chemical compounds added to the paint to give itsome desired effects. It is generally added in very less quantity. For instance, when driers are added to the paint, they accelerate drying of the paint by catalysing oxidation of the binder.

Some famous Additives that are used in paint are:

- Plasticisers
- Flow control agents
- Defoamers
- UV Stabilizers
- Corrosion Inhibitors
- Limestone
- Talc
- Fungicides, Biocides, Insecticides
- Emulsifiers



VEHICLE:-

S. No.	Name	Description
1.	Linseed Oil	This is the most common material used as vehicle of a paint. It is extracted from flax seeds. The linseed oil prepared from fine full-grown ripe seeds is clear, transparent, pale sweet to the taste and practically odourless. It is used in various grades.
(a)	Raw Linseed Oil	It is thin, odourless, transparent and brilliant. It takes long time for drying. It is used for delicate tints and interior painting work.
(b)	Boiled Linseed Oil	This oil is thicker and darkly coloured than raw oil. It dries quickly. It is prepared by adding some quantity of drier such as litharge or red lead to the raw oil. It cannot be used for interior delicate work. It is used for exterior surfaces.
(c)	Pale Boiled Linseed Oil	It is similar to boiled linseed oil except that it is not dark in colour. It is more suitable for painting plastered or metal surfaces.
(d)	Double Boiled Linseed Oil	It dries very quickly. It has the same colour and transparency as raw linseed oil but odour is different. It is suitable for painting external work. However, it requires a thinning agent like turpentine.
(e)	Stand Oil	Formerly this oil was prepared by exposing raw linseed oil to sun till it thickened like honey. As present, the heat treatment is used for this purpose. This oil dries slowly and provides a durable, clear and shining finish.
2.	Tung Oil	This is much superior to linseed oil and is used in making superior paints and varnishes.
3.	Poppy Oil	This oil prepared from poppy seeds. It dries slowly. But its colours last long. It is used for making paints of very delicate colours.
4.	Nut Oil	This is extracted from ordinary walnuts. It has rapid drying qualities but is less durable. It is colourless and cheap. It is used for making white and light coloured paints for ordinary works.

Enamel Paint

- **Enamel paint can be defined as the oil-based paint that is used when a highly glossy finish is required.**
 - It consists of white lead, zinc white, resins and other petroleum products.
 - It has characteristic coverage and colour retention property.
 - It is slow-drying paint as it dries very slowly.
 - It is hard in nature and provides a glossy and opaque finish to the surface where it is applied.
 - It also offers excellent durability and stain resisting properties.
 - It may also be water-based.
- Addition of varnish in ordinary oil-based paint
- 90% solvent & binders, 10% pigments & additives
 - solvents => hydrocarbons toluene, methyl ethyl ketone
 - binders => vegetable oils, alkyds and acrylics, vinyl acrylics
 - Pigments => clay, calcium carbonate, mica, silica's and talc's
 - additives => diatomaceous earth, talc, lime and barite
- Enamel Paint are
 - High gloss,
 - hard-drying film covering that varies in composition depending on the intended use of the product.
 - Functional, multipurpose and dry to shiny finishes.
 - Hard-wearing paint surface product



Composition of Enamel Paint:-

Base: White lead, or red lead, or zinc oxide, or iron oxide, or titanium white, or aluminium powder, or lithophone may be used as the base.

Vehicle/Binder: Mostly Linseed oil, or alkyd resins, or acrylic resin or epoxy resins are used as the vehicle.

Extender/inert Filler: Usually, the coloured particles are used as the extenders.

Solvent/Thinner: Mostly, the varnish or white spirit is used as the solvent or thinner.

Colouring Pigments: The fine powder of mineral colour pigments is used as the colouring pigments.

Additives: Various drying additives or pigments such as lead, copper, cobalt, manganese, zirconium etc may be used as the additives.

VARNISH:-

- The term varnish is used to indicate the solution of resins or resins substances prepared either in alcohol. oil or turpentine.
- The type of solvent depends upon the type of resin used. The Oil dries with time and the other solvents evaporate leaving behind a solid transparent resin film over the The solid transparent resin film protects. pressures and beautifies the surface. For rapid drying, driers such as latharage, lead acetate, etc. are used.

Composition of Varnish:-

- There are many different types of drying oils, including linseed oil, tung oil, and walnut oil. These contain high levels of polyunsaturated fatty acids.



Resin

- Resins that are used in varnishes include amber, kauri gum, dammar, copal, rosin (pine resin), sandarac, balsam, elemi, mastic, and others. Shellac is also a resin.

Solvent (traditionally turpentine)

- Traditionally, natural (organic) turpentine was used as the thinner or solvent, but has been replaced by several mineral-based turpentine substitutes such as white spirit or “paint thinner”, also known as “mineral spirit”.

Types of Paint:-

1. Aluminium Paint

- The very finely ground aluminium is suspended in either quick-drying spirit varnish or slow-drying oil varnish as per requirement. The spirit or oil evaporates and a thin metallic film of aluminium is formed on the surface. Paint has the following qualities —
- It protects the iron and steel from corrosion in a better way than any other paint. It possesses good weather-resisting and water proofing qualities.
- Due to its brilliant silvery shiny texture, it is visible even in darkness and also provides a good appearance to the surface being painted. It possesses a high spreading or covering power.
- The aluminium paint is widely used for painting gas tanks, hot water pipes, marine piers, oil storage tanks, radiators etc.

2. Anti-Corrosive Paint

- This paint mainly consists of oil, a strong drier and a colouring pigment mixed with very fine sand. This paint is cheaper than white lead. It lasts for a long period and gives black appearance to the surface being painted. This paint is generally used for external work. This is used to protect and preserve the structural steel work against the adverse effects of weather, fumes, acidic, corrosive chemicals etc.

3. Asbestos Paint

- This paint consists of fibrous asbestos as the main ingredient of the paint. It possesses the qualities of retarding the action of fire and of resisting the effects of water, steam and acidic gases. It is especially suitable for repairing metal roofs to stop leakages.



4. Bituminous and Tar Paints

- This paint is prepared by dissolving asphalt or mineral pitches or vegetable bitumen in any type of oil or petroleum. A variety of bituminous paints is available. The paint presents a black appearance and it is used for painting ironwork under water.

5. Cellulose Paint:-

- This paint is different from ordinary oil paints and varnishes. A cellulose paint hardens by evaporation of thinner or solvent used, whereas ordinary paints harden by oxidation. Cellulose paints are far superior to ordinary oil paints though little costly

6. Enamel Paint

- This paint consists Of metallic oxide (white lead or zinc white) ground with a small quantity of oil and mixed with petroleum spirit holding resinous matter in solutions (i.e. enamel paint has four constituents viz. metallic oxide. oil. petroleum spirit and resinous matter). This paint is available in market in readymade form in a variety Of colours. This paint has the following qualities —
- It dries slowly but on drying it produces a very hard. impervious. glossy. elastic. smooth and durable film over the surface being painted.
- The enamel painted surface is not affected by hot and cold water, steam, acids. alkalies. fumes of gas etc.
- This paint has the property of now and leaves no brush marks. like other oil paints. Moreover, the enamel painted surface is easily washable.

7. Oil Paint

- This is the ordinary paint and it is generally applied in three coats of varying composition. They are respectively termed as primes. undercoats and finishing coats. This paint is cheap and easy to apply and it possess good opacity and low gloss.
- It should be remembered that the oil paint should not be applied during humid and damp weather. The presence of dampness on wall surface also considerably affects the life of oil paint coating. It is advisable to redecorate the surfaces finished with oil paint with a coating of fresh oil paint only. The layer of old oil paint serves as a foundation for the fresh paint.



8. Plastic Paint

- This paint essentially consists of a variety of plastics as the base which forms the main constituent for the paint. This paint is available in the market in a wide range of shades under different trade names. When these paints are thinned with water, they are known as plastic emulsion paints. The plastic paints have the qualities of quick-drying, high covering power and decorative appearance. These paints afford good adhesion to the surfaces being painted. These plastic paints are widely used for painting showrooms, auditoriums, offices, cinema halls, etc. where attractive appearance is desired. These paints are either applied by brushes or spraying equipment i.e. spray gun.

TYPES OF ENAMELS:-

There are various types of enamel paints, so here's the list:

1. **Alkyd enamel** – is the most popular. Alkyd enamel paint has a number of advantages – they are durable, easy to apply, and have an elastic structure and dry quickly. They are very often used in rooms with high humidity, e.g. bathrooms or swimming pools, as well as tolerate changes in temperature and moisture.
2. **Nitro enamel** – the basis of enamel paint of this type is cellulose nitrate. Their peculiarity is that they almost instantly dry under normal conditions at room temperature. However, the environmental pollution of enamel paints of this type is very large. Therefore, their use is in many countries severely restricted or even prohibited. They are often used for surfaces of wood. The application of the coating is carried out mainly with the help of special nozzles, so as fast drying paint is badly applied the usual physical way;
3. **Polyurethane enamel** – the main advantage is durability. In this regard, they are used for painting floors in the rooms of common use, that is with high traffic, such as corridors in schools or in museums. On the second day after the completion of works, the painted surface is ready for operation. Remember safety, enamel paints are toxic, so working with them needs special protection, gloves and protective glasses. The room during and after completion of works it is necessary to ventilate.



TYPES OF VARNISHES

- Depending upon the solvent, the varnishes are classified into the following categories:
 1. **Oil varnish:** Uses linseed oil and takes about 24 hours to dry. Hard resins such as amber and copal are dissolved in linseed oil. If the varnish is found unworkable, a small amount of turpentine oil may be added. It is suitable both for interior and external works.
 2. **Flat varnish:** Materials such as wax, metallic soap or finely divided silica when added to varnish produce a dull appearance or drying and are known as flat varnish.
 3. **spirit varnish:** Spirit varnish is resin of soft variety such as shellac dissolved in spirit. The examples are French polish, lacquer and shellac varnish. It dries very quickly. These are not durable and are easily affected by weathering action.
 4. **Spar varnish:** Spar varnish derives its name from its use on spars and other parts of ships. It gives sticky effect in warm weather and is not used indoors.
 5. **Water varnish:** Water varnish is shellac dissolved in hot water to which enough quantity of either ammonia, borax, soda or potash is added. These are used for varnishing maps and pictures.
 6. **Asphalt varnish:** Asphalt varnish is made by dissolving melted hard asphalt in linseed oil with a thinner such as turpentine or petroleum spirit. It is used over shop fabricated steel works.



Emulsion Paint:-

Emulsion paint is water-based paint, which contains small polymer particles that have pigments inside. The particles containing pigment are suspended in water. After the paint dries, the particles combine, producing a film of paint on the wall. Emulsion paint can be used for the exterior as well as the interior of the house.



What does emulsion paint contain?(Composition of Emulsion paint)

If you do a chemical breakup of this product, you will find it contains:

- **25% Pigment:** Iron oxide is used for the yellows, browns, and reds, titanium dioxide is utilized for white colour, carbon for black, and chromium oxide for green shades.
- **45% Solvent:** Almost half of the emulsion paint consists of water.
- **25% Binders:** The pigments are surrounded by acrylic or epoxy polymers that fuse the paint to the walls.
- **5% Other Additives:** Biocides in the emulsion paint control growth of fungi and algae on the walls

How to apply emulsion paint :-

- Emulsion paints are not only easy to apply, but they also dry faster than other oil-based and water-based paints. You can use a brush or a roller to apply the paint. Interior emulsion paint is easy to use if you are considering painting your room yourself. All you need to do is follow the instructions given on our product guides.
- It is important to mention here that these paints are not ready to use. Before application, you have to add a thinner, in this case, water. If thinner is not used, there are chances that your wall will not have a smooth finish, and defects may appear.
- You can apply emulsion paint to old as well as new plastered walls and surfaces.



What are the properties of emulsion paint?

When you compare emulsion paint with oil-based paints, you will find that they are less toxic i.e. products with minimum volatile organic compounds.

- Emulsion paints have a washability marker of medium to a high level. Washability has a lot to do with surface luster. While most sheen paints can be wiped, some emulsion paints can be washed, depending on the product.
- Emulsion paint is available in various finishes, such as glossy, semi-glossy, eggshell, matt, and smooth.
- The quality or colour of the paint is not affected when it is exposed to water, making it easy to clean.
- Various techniques can be used to apply the paint. Spraying, dip, flow, roller, and brushing are some of the methods you can use.
- Emulsion paint is non-inflammable and has less odor.
- You can use emulsion paint on your walls and ceiling as it is thick and easy to use. It is ideal for humid environments like the kitchen and the bathroom.

Types of emulsion paint

- There are many types of emulsion paint. These paints are formulated for a variety of purposes. As such, they have different properties. The properties of emulsion paint used for a home's exterior are different from paint made for the interior.
- Each finish has its benefits. Matte finish is ideal for imperfect walls, while soft sheen has a longer life. On the other hand, glossy paint is ideal for perfectly finished walls as imperfections tend to become obvious with a glossy finish.

1. Emulsion paint for interiors

This paint is manufactured keeping in mind that it may need scrubbing from time to time. It is also stain-resistant. A firmer resin is used for interiors as the paint will not be exposed to varying climatic conditions and changing temperatures.



2. Emulsion paint for exteriors

- Paints made for the outside of a home must be able to tackle mildew and fading. A softer resin is used for this paint so that it can take temperature changes in its stride. The paint must be resistant to peeling and tough enough to not chip or become dull due to sunlight. The paint might need to be waterproof as it will be exposed to rain.

DISTEMPER:-

- Distempers are considered to be water paints, consisting of whiting (i.e., powdered chalk), glue U casein as a binder and suitable proportion of fast colouring pigments (if desired). These distempers a cheap, durable and easily applied decoration for internal use on plastered. cement concrete and various wall board surfaces
- '***Distemping***' is the process of applying distempers over the various easily and with lesser coat than paints and varnishes, to safeguard them against weather effects and improve their appearance.

Applications:-

The process of distemping is carried out in the following stage

- Stage I. Preparation of surface. If the receiving surface is rough. it should be rubbed down smooth with a sand paper and then cleaned. The surface should be perfectly dry before applying the distempers. A new plastered surface for distemping should be prepared considering the following Important practical aspects:
 - (i) New plastered surfaces should be allowed to dry for atleast two months before applying distemper.
 - (ii) New lime plastered surfaces should be washed with a solution of 1 to 50 sulphuric acid and left for 24 hours. after which the walls should be thoroughly washed with clean water.
- New cement plastered surfaces should be washed with a solution Of Zinc sulphate (one kg zinc sulphate in litres Of water) and then allowed to dry.
- The treated surface should be wiped with clean cloth to remove any efflorescence patches before distemping.



- In case of distempering old surfaces at first all dust, loose materials scales. etc are removed by wire brushes. The surface irregularities due to cracks. holes. etc. are then repaired by lime putty or plaster of paris (i.e. gypsum plaster). The whole surface is rubbed down by a sand paper, washed clean and allowed to dry. If the surface to be distempered. whether new or old. is tough then a coat of whiting (powdered chalk) mixed with a solution of glue should be applied.
- Step II. **Priming coat.**
 - After preparing the surface. a priming coat is applied and then left to dry. If ready-made distempers are used then priming coat all consist of materials as recommended by the makers of distempers. When local materials are used in preparing distempers. then milk is generally used for priming coat (one litre of milk covers a surface area of 10 m²).
- Step III. **Coats of Distemper.**
 - Over the priming coat. coats of distemper of good quality should be applied uniformly in succession. One coat over the other is applied only when the former one gets completely dried and becomes hard.
 - On new lime plastered walls. distempers should be applied in 2 or 3 coats over one coat Of priming. On old lime plastered walls which are covered with one or two coats of hard dry wash. one coat of distemper without priming can be used, but a coating of warm glue prior to the application of distemper is useful.
 - In applying the distemper. the brush should first be applied horizontally and then immediately creased off vertically.
- **Distempers and their compositions**
 - A distemper is composed of base (whiting or chalk). glue (binder), water (carrier or thinner) and a colouring pigment. Distempers are available in the market in a variety of shades under different trade names. They may either be in powder form or paste form. These distempers are required to be mixed with hot water before use.



- The various forms of distempers are
 - **White Distempers** — They are made by mixing a whiting (i.e. powdered chalk) and glue size.
 - **Coloured Distempers** — They are prepared by mixing the desired colouring pigments to the whiting before mixing it with glue size.
 - **Oil Bound Distempers** — There is a variety of oil paints in which the drying oil is so treated that it mixes with water. Such distempers are diluted or thinned with water when required. These distempers, on drying, form a durable and washable coating.

1. Emulsion Paints	2. Distemper Paints
Advantages:- ● They are water and chemical resistant. ● You can use them easily due to their thickness. ● The paints are durable and can last for few years. ● You can apply them to papered walls and wooden furniture. ● As these paints are resistant to water, they are easier to clean.	Advantages:- ● It can be applied directly on cement. ● Distemper paint is cheaper than other alternatives. ● The paint does not dry or crack in the sunlight.
Disadvantages:- ● The paints are relatively expensive. ● They take a longer time to dry. ● They cannot be applied directly to the cement and require quotes of primer and putty first. ● There are a limited number of shades and colours available.	Disadvantages:- ● They cannot be washed/ cleaned often. ● These paints have a lesser life span. ● The colours fade faster than that of the emulsion paints. ● They have a distinct smell. ● The finish isn't as smooth as other alternatives. ● The distemper paint colour will peel off when wet. 

French polishing:-

- It is a wood finishing technique that results in a very high gloss surface, with a deep colour and chatoyancy. French polishing consists of applying many thin coats of shellac dissolved in denatured alcohol using a rubbing pad lubricated with one of a variety of oils. The rubbing pad is made of absorbent cotton or wool cloth wadding inside of a piece of fabric (usually soft cotton cloth) and is commonly referred to as a *fad*, also called a rubber, tampon or *muñeca* (Spanish for "rag doll")
- *French polish* is a process, not a material. The main material is shellac, although there are several other shellac-based finishes, not all of which class as French polishing.
- The French Polish technique is an excellent method to accent exotic wood grain. The finish is softer than modern varnishes and lacquers, and is particularly sensitive to spills of water or alcohol, which may produce white cloudy marks, as does heat damage. On the other hand, French Polish is simpler to repair, as opposed to traditional & modern varnish finishes.

Pros and Cons of French Polish

- There are scenarios in which it is not a suitable technique for your wooden furniture or accent.
- French-polished shellac is durable and doesn't require much in the way of polishing once dry. It's flexible, so resists cracking, scratches, and wear—a definite advantage if you drop your keys onto a shellacked table,
 - for example. Shellac also dries quickly and is nontoxic. It won't yellow over time, as varnish will, and it's fairly easy to patch up your French-polished piece without leaving obvious signs of repair. While shellac is naturally amber to orange, you'll also find bleached shellac that's useful over light-colored wood like maple.

- On the *downside*, however, shellac burns if exposed to high heat—such as a hot plate set down without a trivet. It also **develops white rings or patches** if subject to high humidity or liquids, meaning it's risky to French polish a coffee table or any piece of furniture that might gather drips or condensation.

- Nor would you want to French polish anything too close to a high-humidity area, such as the bathroom or kitchen. In fact, *before you even start your French-polishing project*, you'll want to check the weather report and postpone if the day calls for rain or high humidity.

- *Finally, shellac is also damaged by alcohol, so this isn't the best choice for counters or furniture in your home bar.*

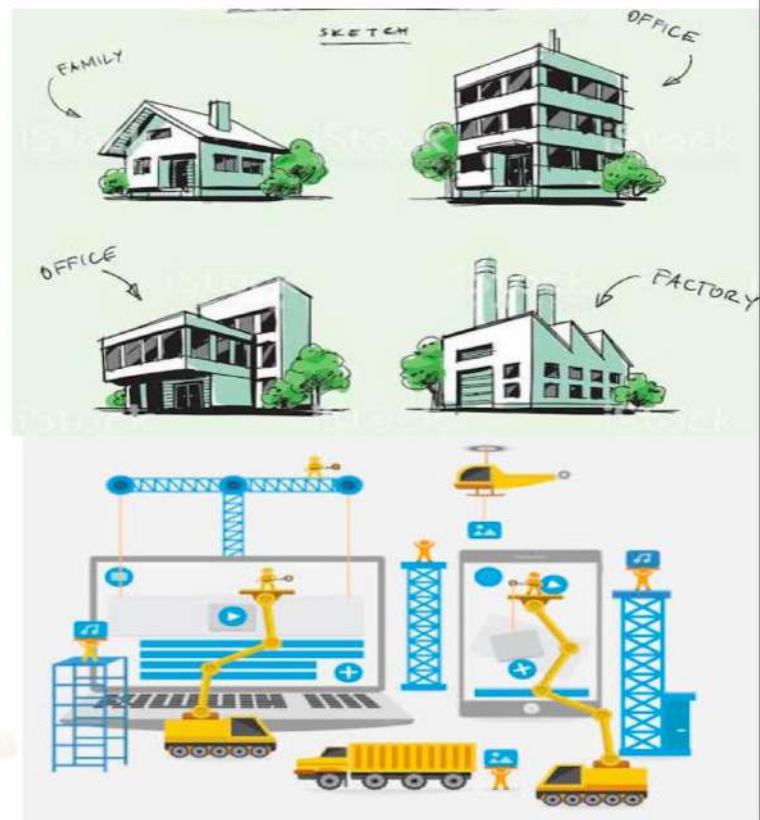




CONSTRUCTION TECHNOLOGY CHAPTER 1

INTRODUCTION

BY:-Shubhashree Maharana



PART: B (CONSTRUCTIONS TECHNOLOGY)

Introduction

1.1 Buildings and classification of buildings based on occupancy

1 .2 Different components of a building.

1 .3 Site investigation — objectives, site reconnaissance and explorations.

1.1 Buildings and classification of buildings based on occupancy:-

Building:-

- The building is defined as any structure for whatsoever purpose and of materials constructed and every part thereof whether used as human habitation or not includes foundations, plinth, walls, floors, roofs, chimneys, Plumbing and building services fixed Platforms, verandah, balcony cornice or Projection, part of a building or anything affixed thereto or any wall enclosing or intended to enclose any land or space and signs and outdoor display structures according to National Building Code of India



As per National Building Code of India, buildings are classified in

- Group A : Residential buildings
- Group B : Educational buildings
- Group C : Institutional buildings
- Group D : . Assembly buildings
- Group E : Business buildings
- Group F : Mercantile buildings
- Group G : Industrial buildings
- Group H : Storage buildings
- Group I : Hazardous buildings.



Apartment



Villa



Bungalow



Nursing home



Museum



School



Archive



library



Capitol



Embassy



Prison



Fire station



Post office

1-1-1. GROUP A: RESIDENTIAL BUILDINGS

- The buildings which are provided with sleeping accommodation for normal residential purposes, with or without cooking or dining or both the facilities, except any buildings classified under Group C.

The buildings of Group A are further sub-divided into five groups as follows:

1. Sub-group A-1 : Lodging or rooming houses
2. Sub-group A-2 one or two family private dwellings
3. Sub-group A-3 : Dormitories
4. Sub-group A-4 : Apartment houses (Flats)
5. Sub-group A-5 : Hotels

1-2-2. GROUP B: EDUCATIONAL BUILDINGS

Any school, college building or day-care centre used for educational purpose for more than 8 hours a week involving assembly for instruction, education or recreation and which is not covered by Group D comes under this group.



Museum



School



Archive



library

1-2-3. GROUP C: INSTITUTIONAL BUILDINGS

These include any building or part thereof, which is used for purposes like medical or other treatment or care of persons suffering from physical or mental illness, diseases or infirmity, care of infants, aged persons, etc.

This group is further divided into three sub-groups as mentioned below:

1. Sub-group C-1 : Hospitals and Sanitaria
2. Sub-group C-2 : Custodial Institutions
3. Sub-group C-3 : Penal Institutions

1-2-4. GROUP D: ASSEMBLY BUILDINGS

- Any building or part of a building like theatres, assembly halls, drama theatres, auditorium, museums, exhibition halls, restaurants, places of worship, dance halls, club house, air terminals, surface and marine public transportation service, recreation piers, sports stadium, gymnasiums, skating rinks, etc., where group of people gather for amusement, recreation, social, religious, patriotic, civil, travel or other similar purposes are included in this group.

1-2-5. GROUP E: BUSINESS BUILDINGS

- Any building or part of a building which is used for the transaction of business (other than that covered by building in Group F), for the keeping of accounts and records and similar purposes, barber shops, beauty parlours, lunch counters serving less than 100 people, is included in this group.

1-2-6. GROUP F: MERCANTILE BUILDINGS

- This sub-group includes any building or part of building, which is used as shops, offices, stores, markets, showrooms for display and sale of merchandise, either wholesale or retail.

1-2-7. GROUP G: INDUSTRIAL BUILDINGS

- This sub-group includes any building or part of a building in which products or materials of all kinds and properties are fabricated, assembled or processed. These include assembly plants, smoke houses, gas plants, refineries, dairies, textile mills and saw mills.

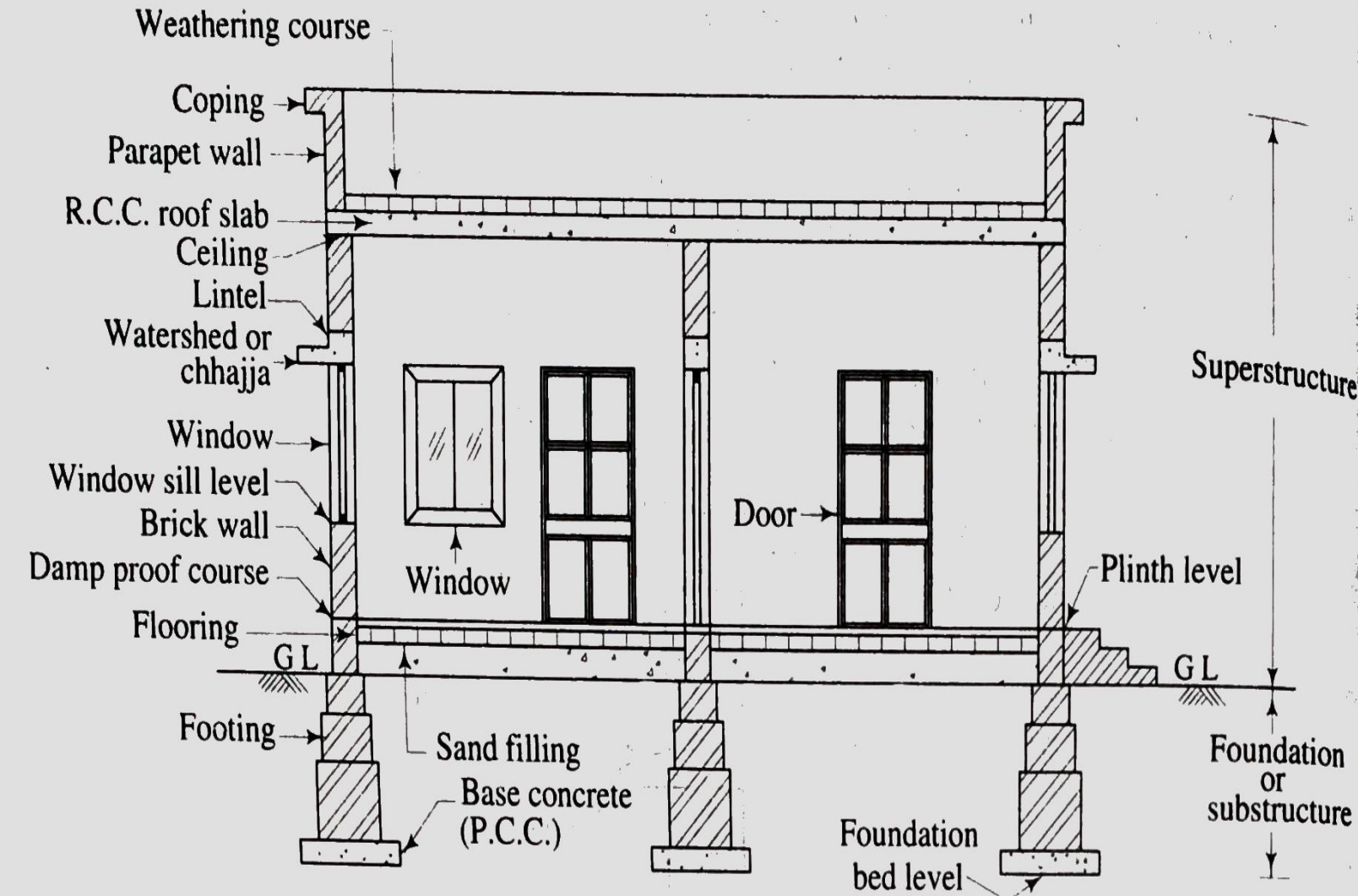
1-2-8. GROUP H: STORAGE BUILDINGS

- This sub-group includes any building or part of a building which primarily used for the storage or sheltering (including servicing, processing or repairs incidental to storage) of goods, wares or merchandise except those that involve highly, combustible or explosive products or materials, vehicles or animals. These include warehouses, cold storages, freight depots, transit sheds, store houses, truck and marine terminals, garages, hangers (other than aircraft repair hangers), grain elevators, bars and stables.

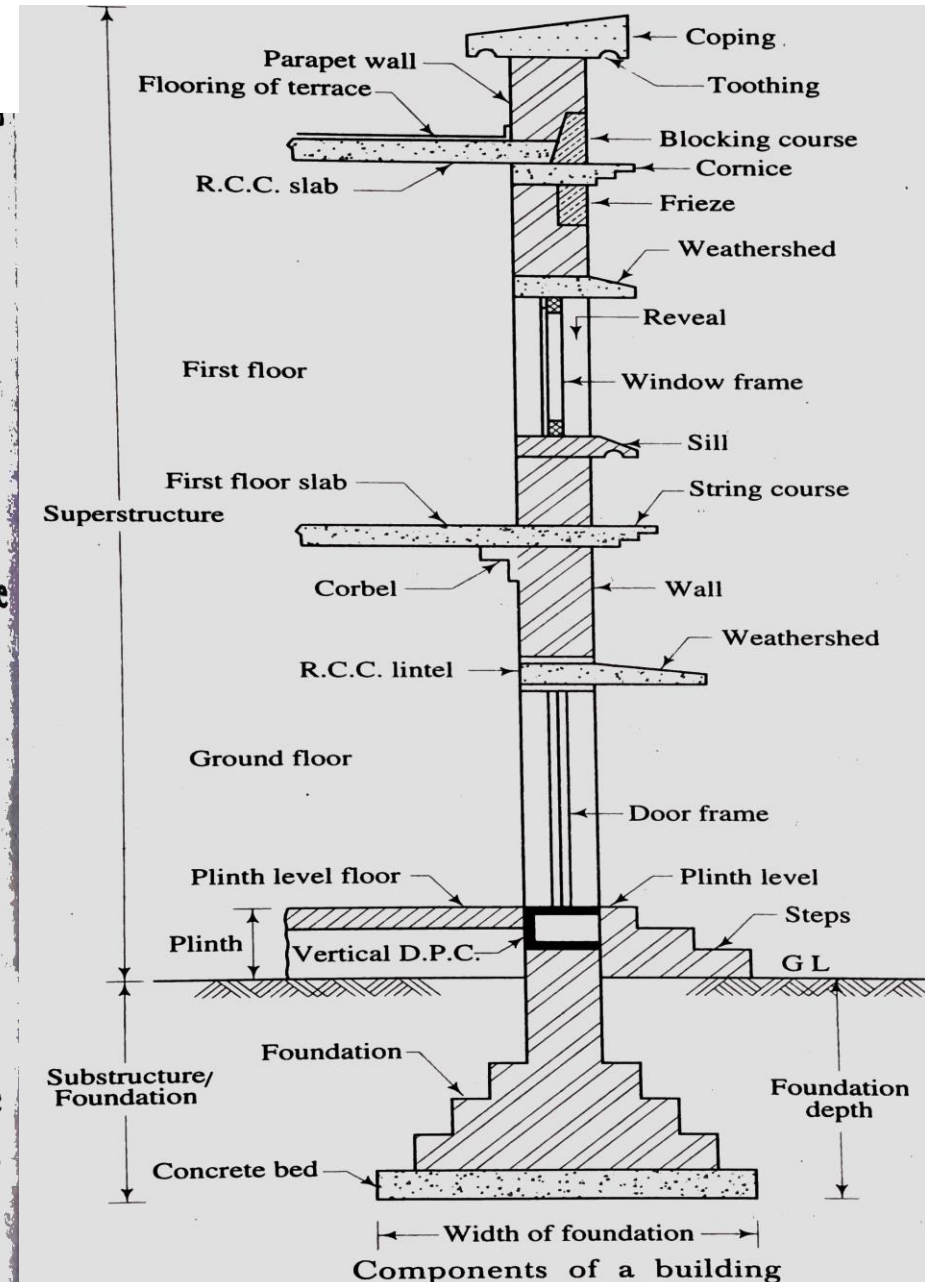
1-2-9. GROUP 1: HAZARDOUS BUILDINGS

- This sub-group includes any building or part of a building which is used as storage, handling, manufacture or processing of highly combustible or explosive materials or products which are liable to burn with extreme rapidity and/or which produce poisonous fumes or explosions or which are highly corrosive, toxic or noxious alkalis, acids or other chemicals producing flame, fumes and explosive, poisonous, irritant gases or which require any material producing explosive mixtures of dust or which result in division of matter into fine particles subject to spontaneous ignition.

COMPONENTS OF BUILDING



Components of a building



Components of a building

1.2 Components Of Building:-

1. Foundation:-

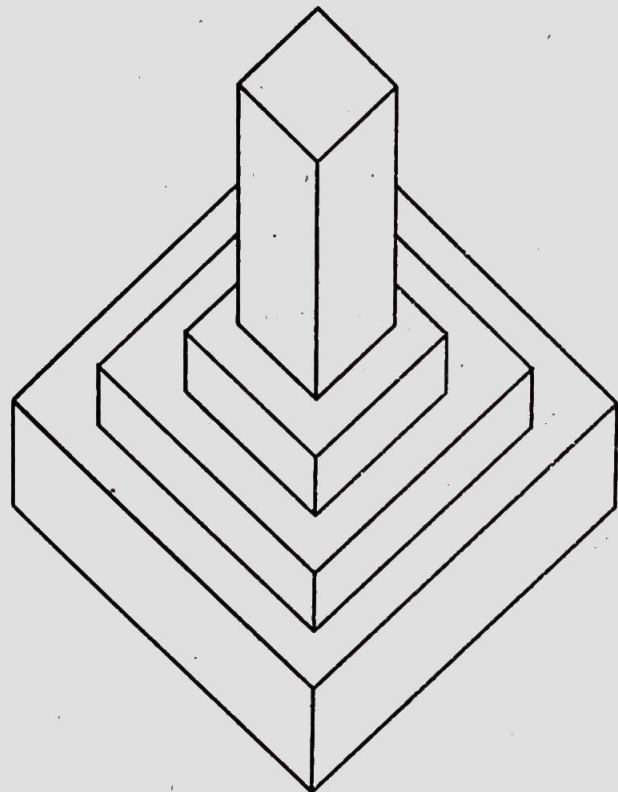
All the loads of superstructure are transmitted to the foundation.

A foundation engineer should know how to examine the soil profile and arrive at a suitable foundation.

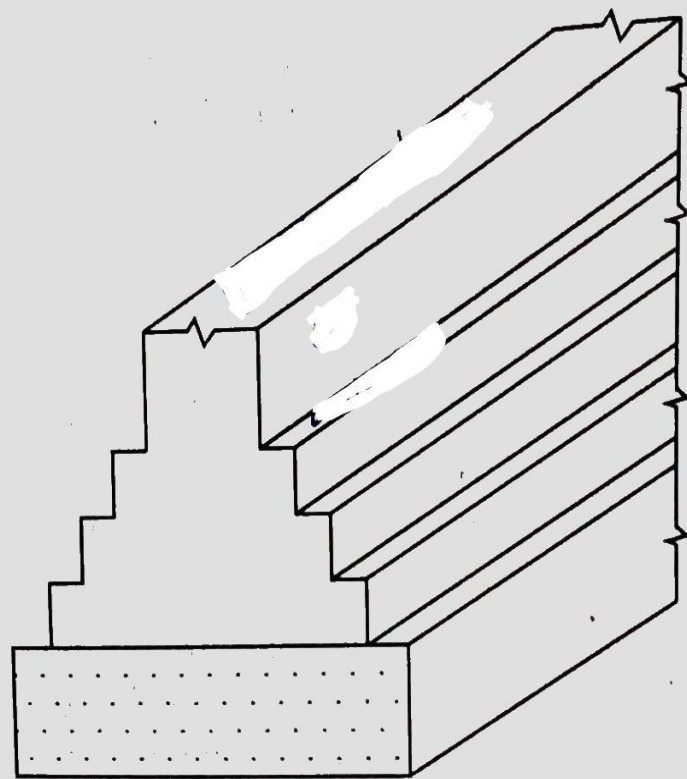
The following are some of the different types of foundation generally used:

1. Strip foundation (shallow foundations)
2. Footing foundation (shallow foundations)
3. Raft foundation (shallow foundations)
4. Pile foundation (deep foundations)
5. Pier foundation (deep foundations).

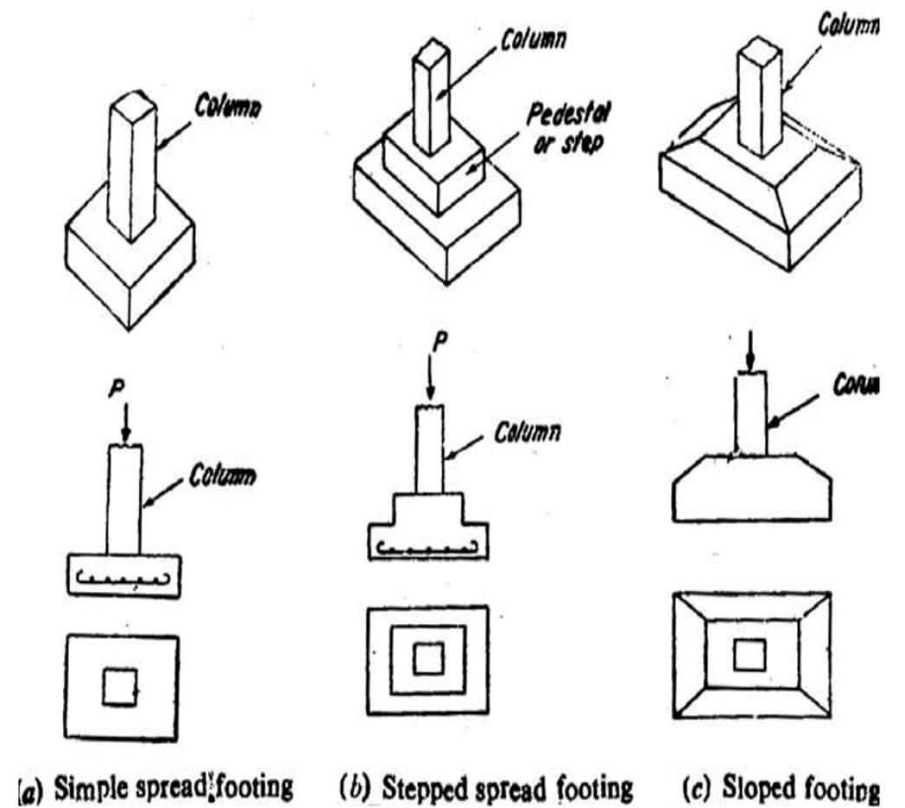
In framed construction, we use footings as the foundation for the column and the brickwork for walls starts from grade beams connecting columns.



Foundation for an R.C.C. pier



Foundation for a masonry pier





Here in the above figure we can clearly see that, two columns footings are overlapping. So instead of providing individual isolated / spread footing , they have provided the combined footing



2. Plinth

The plinth is a dividing line between the substructure and superstructure. Thus, the projecting part of the wall above the ground level to the floor level is the plinth. The plinth is usually kept at least 45 cm (1.5 ft) above the general ground level of the building.

3. Plinth Beam.

It is capped by a beam called plinth beam.

The provision of a plinth beam and damp-proof course at plinth level are very important in building construction.

4. Damp Proof Course (D.P.C).

The damp proof course is a layer provided in building to prevent the entering of dampness from the ground to the building components.



5. Walls and Columns.

- Walls are mostly made of masonry. It may be of brick, block-work, stonework, etc. Buildings may also be constructed as a framed structure with columns and footings and then Walled.
- Most of the flats and high-rise buildings are built this way. In many places in the masonry, we use arches and lintels.

6. Floors.

- It is the place where the inhabitants perform their most activities.
- It is ***constructed on the filling and laid over the plinth level.***
- Floors are usually ***made from different types of materials, such as, timber, brick, R.C.C.***
- Top floors are nowadays usually made of reinforced concrete.

7. Roof.

- The most important item in housing is to have a “roof over one’s head.”
- A roof is a layer which ***covers the structure from the top.***
- It also **prevents** the building and inhabitants from the ***ill effects of the environment.***
- Depending on the finances available and also the climatic conditions, we can have different kinds of roofs

8. Fabrication of Doors and Windows.

- Openings are *necessary* in buildings *for passages inside and outside the buildings*.
- We also need windows for *lighting and ventilation*.
- A detailed study of doors and windows is an important part of building construction as the *expenditure on this item alone can go up to 15 to 20 percent of the total cost of civil works*.
- Traditionally, doors and windows were made of wood and hence, this work is sometimes referred to as *woodwork* in buildings.
- Other woodworks like provision of cupboards are also important, but it comes under the subject of interior decoration.

9. Stairs and Lifts.

- For moving up and down in between floors we use **Stairs and for more than 3 floor we use Lift or escalators**.
- Knowledge of various elements of a staircase and the construction of a simple staircase is essential to all those involved in building construction.
- Study of the layout and design of ornamental staircases is a special subject.
- Usually, vertical transportation devices like electric lifts are to be provided in buildings having more than four floors including the ground floor.



10. Building Finishes.

The final appearance of a building depends very much on its finishing.

We have to deal with the following:

1. Plastering and pointing

2. Painting of walls, woodwork, grillwork, etc.

It is essential that we have a knowledge of the finishing to be used on the various materials of construction such as plaster, wood, metals, etc.

11. Building Services.

- Water supply, drainage, sanitation, electric supply lifts, external works, construction of cupboard, etc. are considered as items outside of civil works and are called building services.
- **Water supply, drainage, and sanitation (building service).**
- These works are considered separate from civil works and are also estimated separately.
- Design and details of these will be studied in public health engineering under building services.

1.3 Site investigation — objectives, site reconnaissance and explorations.

- *Site investigation or Sub-Soil explorations are done for obtaining the information about subsurface conditions at the site proposed for construction.*
- Soil exploration consists of determining the profile of the natural soil deposits at the site, taking the soil samples and determining the engineering properties of soils using laboratory tests as well as in-situ testing methods.

Objectives of Site Investigation

Following are the objectives of site investigation or subsurface exploration.

- To know about the **order of occurrence of soil and rock strata.**
- To know about the **location of the groundwater table level** and its variations.
- To determine engineering properties of soil.
- To select a suitable **type of foundation.**
- To estimate the probable and **maximum differential settlements.**
- To find the **bearing capacity of the soil.**
- To predict the lateral earth pressure against retaining walls and abutments.
- To select suitable **soil improvement techniques.**
- To select suitable construction equipment.
- To forecast problems occurring in foundation.

Stages in Site Investigation

Site investigation or sub-soil exploration is carried out stage-wise as given below.

- Site Reconnaissance
- Preliminary site exploration
- Detailed exploration
- Preparation of soil investigation report

1. Site Reconnaissance

- Site reconnaissance is the first ***stage of site investigation***.
- In this stage, visual inspection of the site is done and ***information about topographical and geological features of the site are collected***.

2. Preliminary Site Exploration

- Preliminary site exploration is carried out for small projects, light structures, highways, airfields, etc. The main objective of preliminary exploration is to obtain an approximate picture of sub-soil conditions at low cost. It is also called general site exploration.
- laboratory tests such as moisture content test, density, unconfined compressive strength test, etc. are conducted.

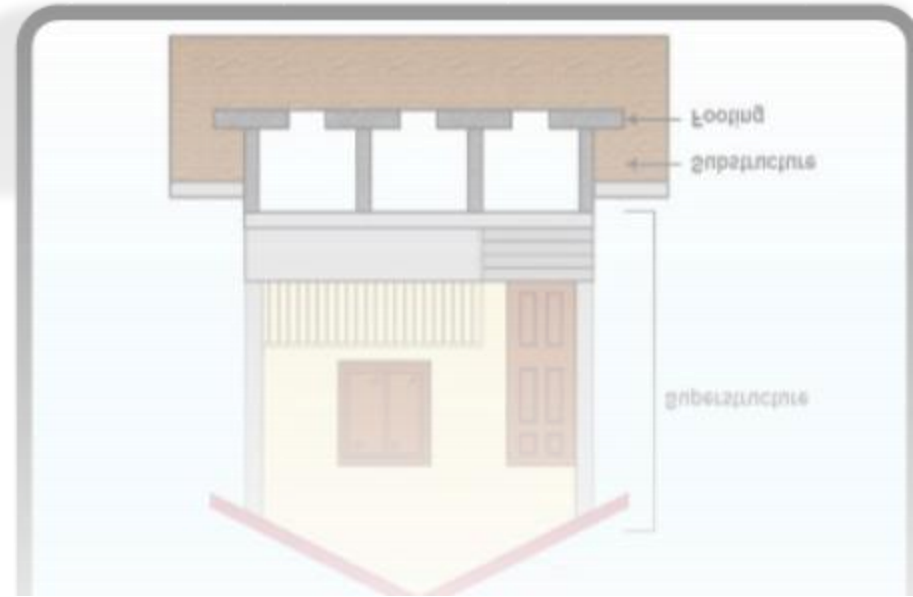
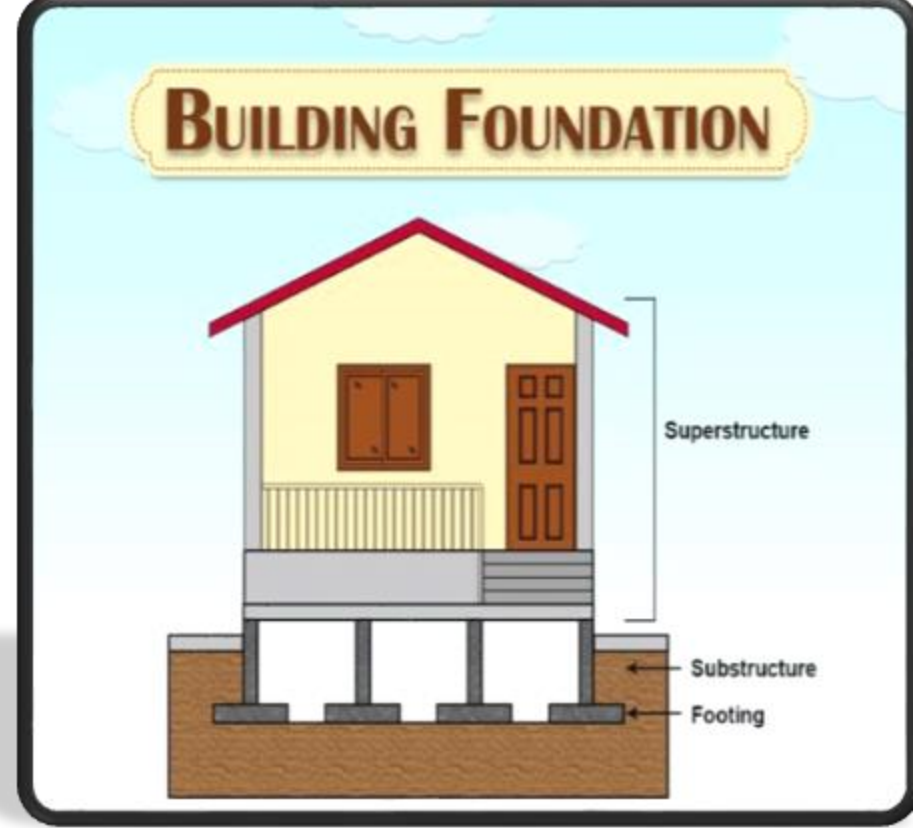
3. Detailed Site Exploration

- Detailed exploration is preferred for complex projects, major engineering works, heavy structures like dams, bridges, high rise buildings, etc. A huge amount of capital is required for a detailed site exploration hence, it is not recommended for minor engineering works where the budget is limited.
- In this stage, numerous field tests such as in-situ vane shear test, plate load test, etc. and laboratory tests such as permeability tests,



CHAPTER 2

FOUNDATION



• *SYLLABUS*:-

Chapter 2 Foundations

- 2.1 Concept of foundation and its purpose
- 2.2 Types of foundations — shallow and deep
- 2.3 Shallow foundation-constructional details of : Spread foundations for walls, thumb rules for depth and width of foundation and thickness of concrete block
- 2.4 Deep foundations: Pile foundations-their suitability, classification of piles based on materials, function and method of installation.

Building has two basic parts

1) Sub structure or foundations

2) Super-structure.

A foundation is that part of the structure which is in direct contact with the ground to which the loads are transmitted.

Super- structure is that part of the structure which is above ground level.

2.1 **Functions of Foundation:**

Reduction of load intensity: Foundations distribute the loads of the Super-structure to a larger area So that the intensity of the load at its base does not exceed the safe bearing capacity of the Sub-soil.

Even distribution of load: Foundations distribute the non-uniform load of the Super structure evenly to sub-soil.

Provision of level surface: It provides levelled and hard surface over which the super structure can be built.

Lateral stability: It anchors the super-structure of the ground, thus imparting lateral stability to the super-structure.

Safety against undermining: It provides the structural safety against undermining or scouring due to burrowing animals and flood water.

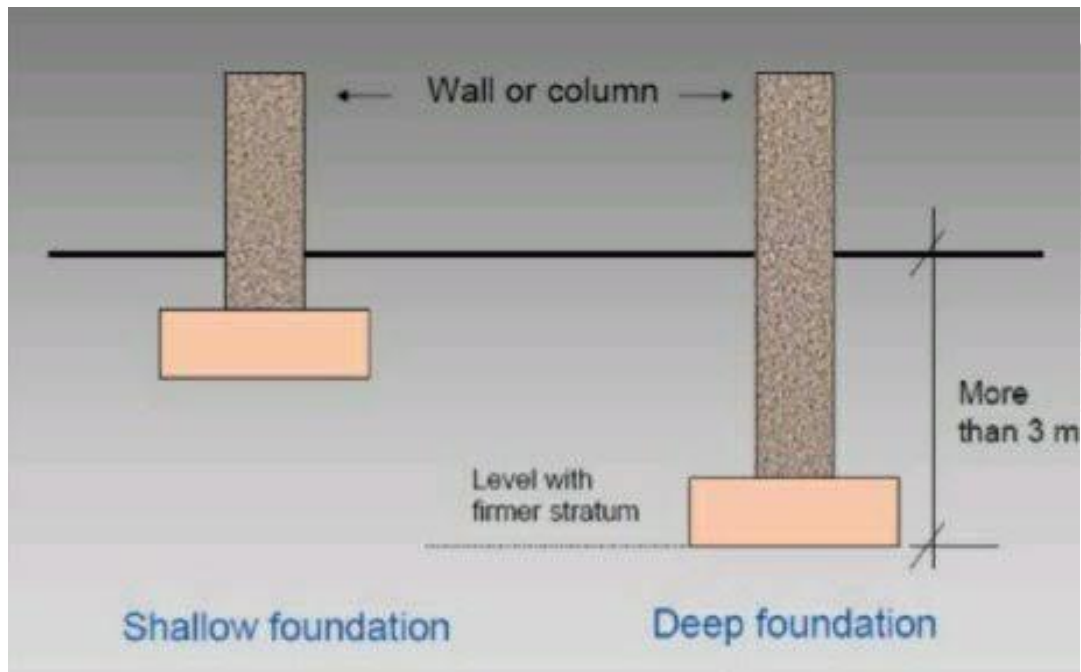
Protection against soil movements: Special foundation measures prevent or minimize the distress (or cracks) in the super-structure due to expansion or contraction of the sub-soil because of movement in some soil like black cotton soil.

Requirements of good Foundation

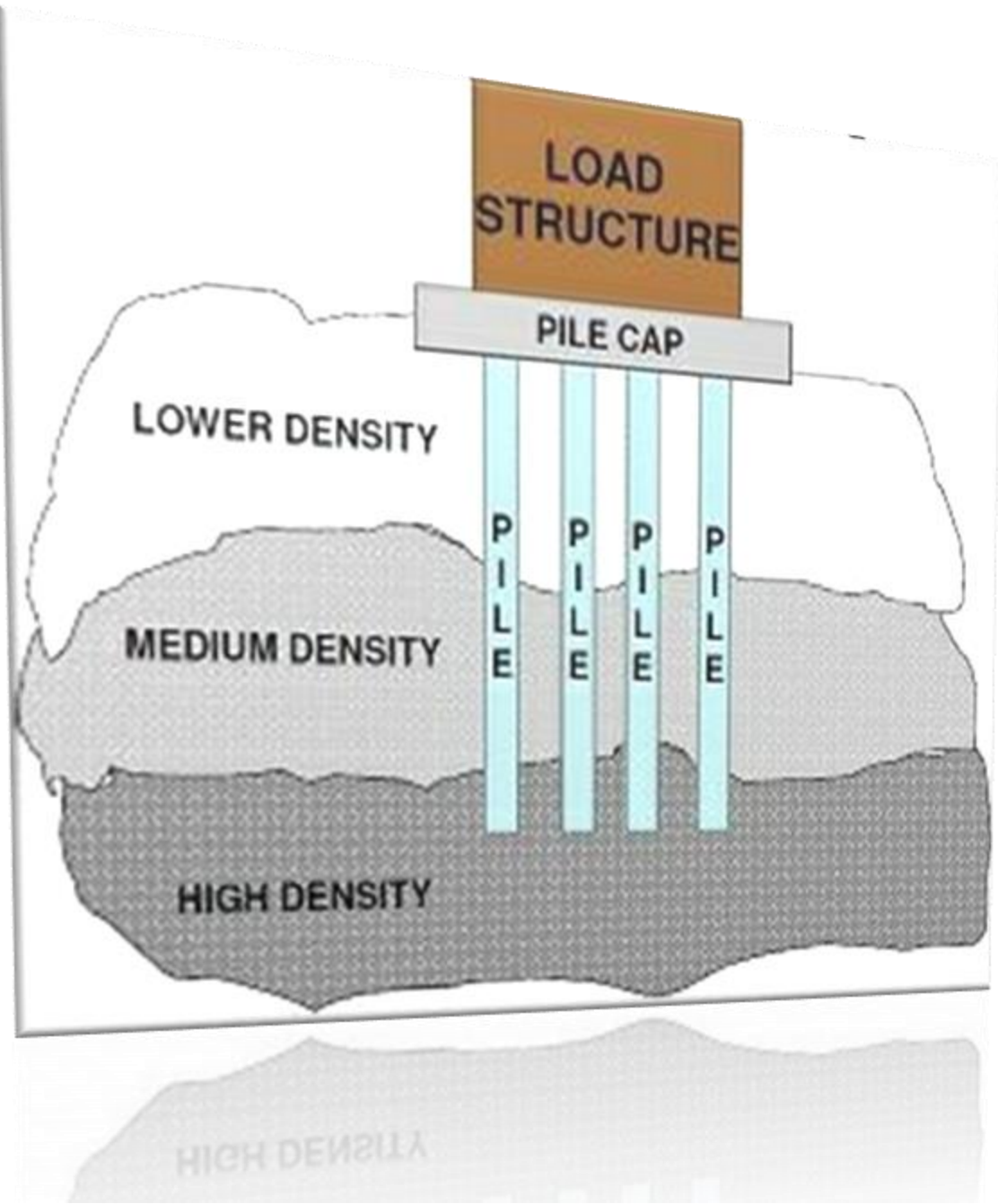
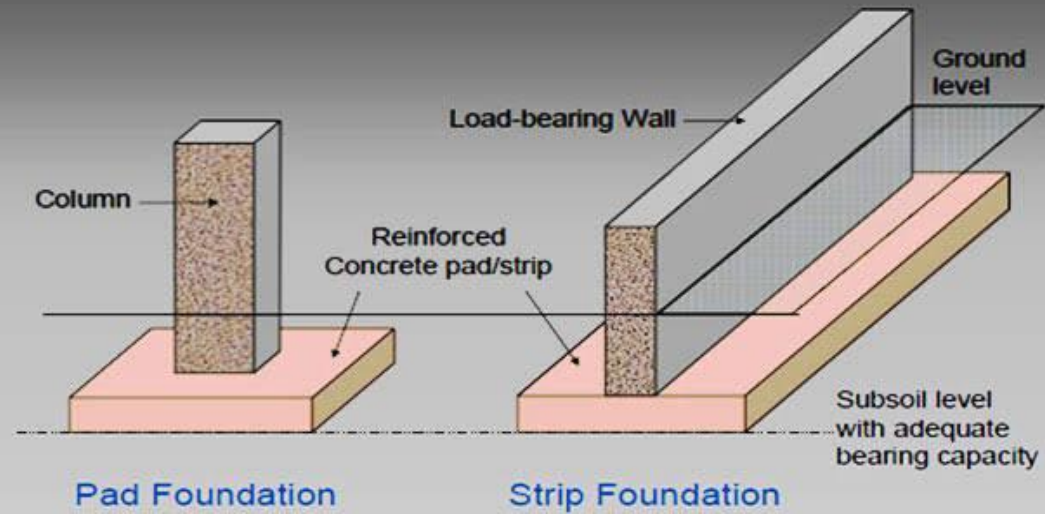
- The foundation shall be constructed to sustain the dead and imposed loads and to transmit these to the sub-soil.
- Foundation base be rigid so that differential settlements are minimized
- Foundation should be taken sufficiently deep to guard the building against damage caused by swelling or shrinking of sub-soil.
- Foundation should be taken sufficiently deep to guard the building against damage caused by swelling or shrinking of sub-soil.
- Foundation should be so located that its performance may not be affected due to any unexpected future influence.

2.2 Types of foundations

- Foundations may be broadly classified into 2 types;
 - a) Shallow Foundations
 - b) Deep Foundation



Types of Shallow Foundation



According to Terzaghi, A foundation is shallow if its depth is equal to or less than its width. Foundation is said to be deep if its depth is greater than its width.

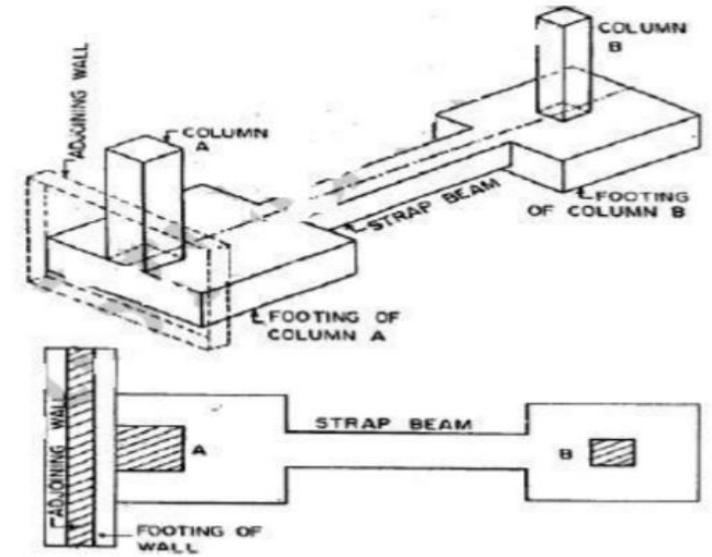
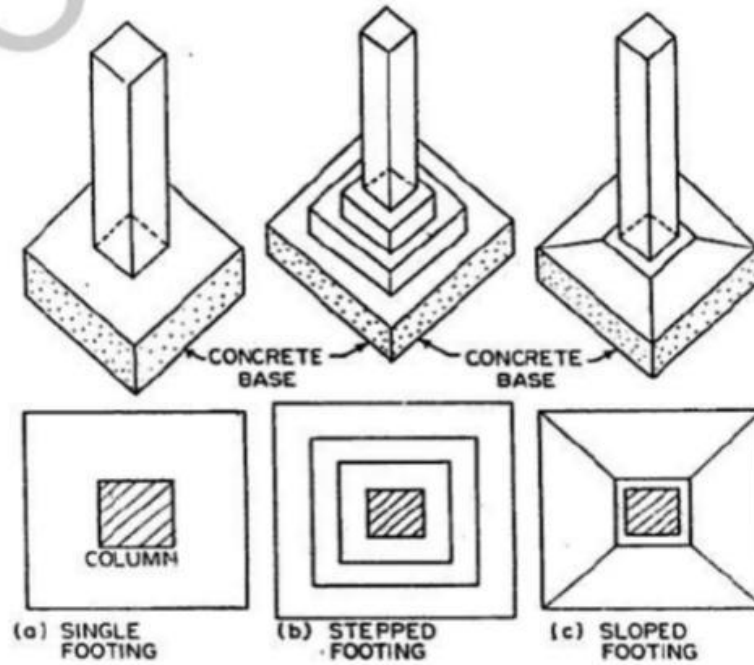
2.1.1 **Shallow foundations**

Types of shallow foundations:

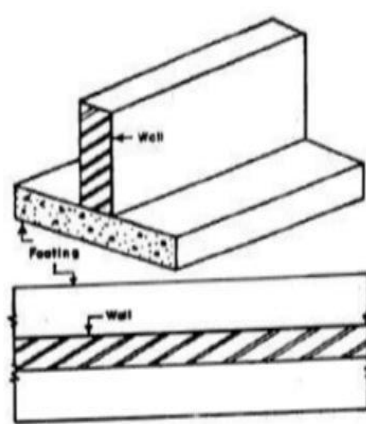
a) **Spread footings**

It spread the super imposed load of wall or column over a large area It supports either a column or wall . It may be of the following types:

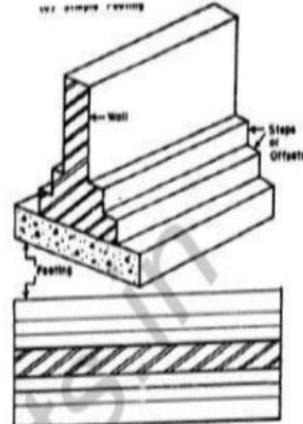
1. Single footing for a column
2. Stepped footing for a column
3. Sloped footing for a column
4. Wall footing without step
5. Stepped footing for wall Grillage



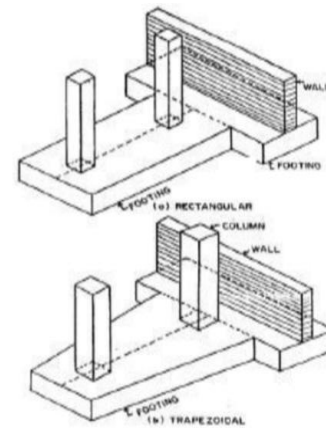
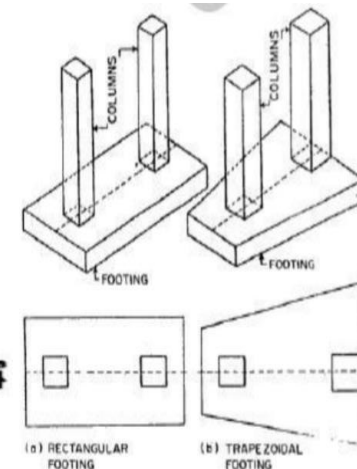
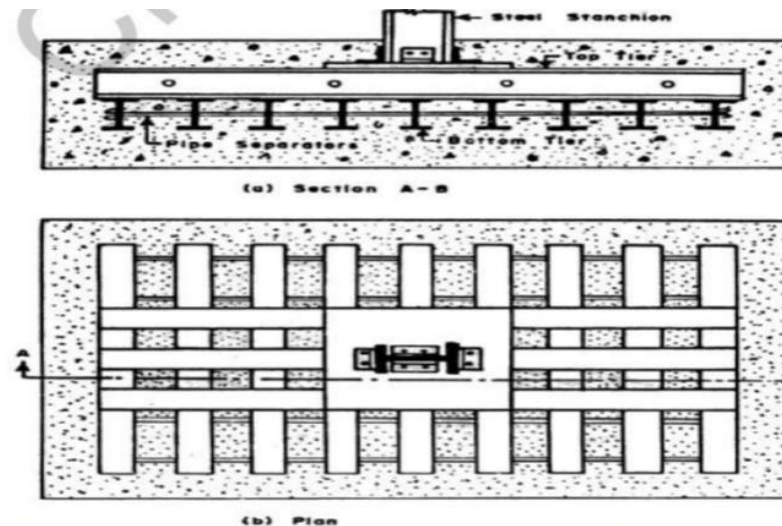
Strap footing



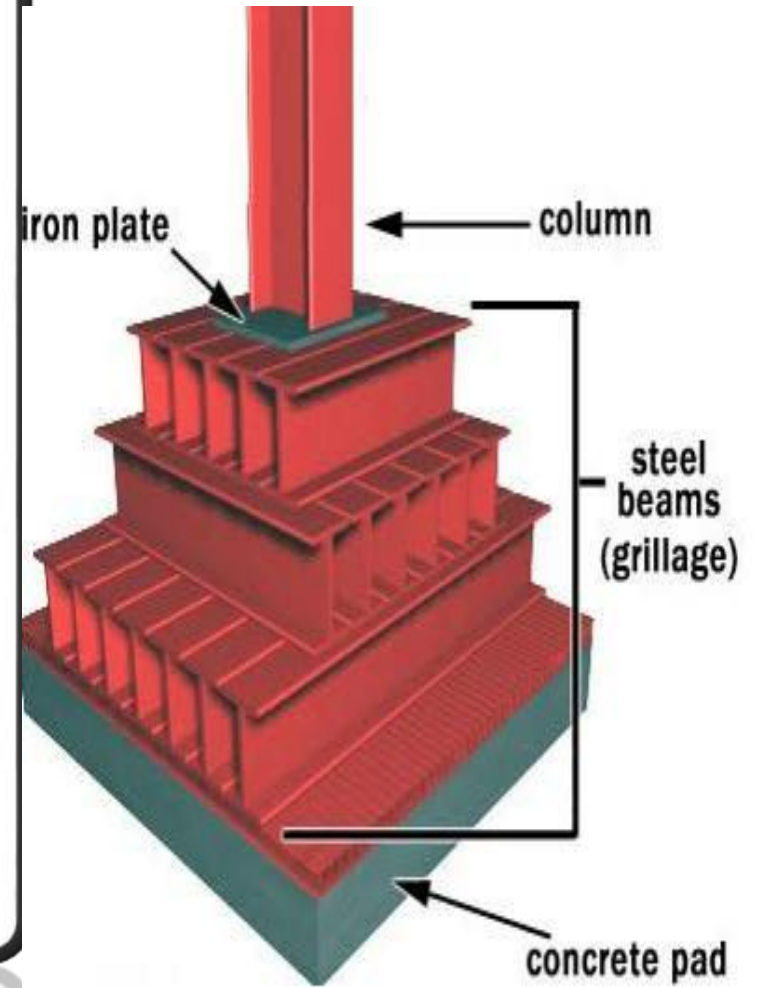
Wall footing without step



Stepped Footing



Combined column wall footings



Grillage Foundation:-

- It is special type of isolated footing
- It is used where the bearing capacity of the soil is poor
- The depth of foundation is limited to 1 to 1.5m
- The load is spread to very large area by means of 2 or more tiers of rolled steel joists and the tiers are embedded in cement concrete to keep the joists in position and to prevent corrosion.

b) Combined footings

- A spread footing which supports 2 or more columns is termed as combined footing.
- It will be in rectangular shape if they carry equal loads
- The design of rigid rectangular combined footing should be done in such a way that center of gravity of column loads coincide with centroid of footing
- It will be trapezoidal if the columns carry unequal loads.
- Sometimes combined footing is provided to both column and a wall.

C) Strap footings

- If the independent footings of two columns are connected by a beam, it is called strap footing
- It is required where the distance between the columns are great so that combined trapezoidal footings become quite narrow with high bending moments.
- Each column is provided with independent footings and a beam is used to connect the two footings
- The strap beam does not remain in contact with soil and thus does not transfer any pressure to the soil
- The strap is assumed to be stiff and transfer the column loads to the soil with equal and uniform pressure

d) Mat foundation

- A raft or mat is a combined footing that converts the entire area beneath a structure and supports all the wall and columns
- It is more economical when the soil pressure is low and it covers one half the area
- They are also used where it is difficult to control differential settlements in soil.
- Raft foundation is also used to reduce settlement by making the weight of structure equal to weight of soil excavated

Thumb rule for Shallow Foundation:-

(1) **Width of foundations:** The width of foundations is decided by adopting the following rules:

(i) If no footings are to be provided to the wall i.e. for simple footing, the width of foundations should be equal to three times the thickness of wall as shown in fig. 5-4.

(ii) The total load including dead load, live load and wind load coming on the wall per metre length or in case of a pier, at the centre of the pier, is worked out. Then the width of

foundation is obtained from the following relations:

For walls, width of foundations = $\frac{\text{total load per metre length}}{\text{allowable bearing capacity of the soil}}$

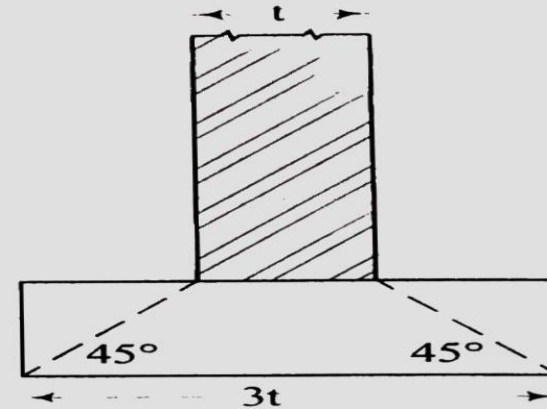
For piers, width of foundations = $\left\{ \frac{\text{total load on the pier}}{\text{allowable bearing capacity of the soil}} \right\}^{\frac{1}{2}}$

(iii) Usually the walls and piers are given footings such that the width at the base becomes equal to twice the width of wall at the plinth level as shown in fig. 5-5. By adding the width of offsets of concrete, the total width of foundations can be obtained for stepped footing.

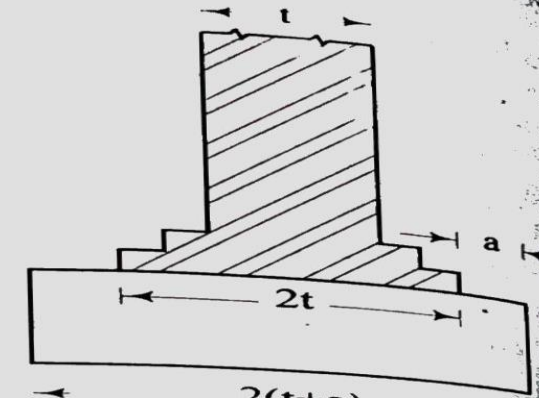
If t = thickness of wall, and
 a = offset of concrete.

width of foundation = $2(t + a)$.

Note: The greater result obtained from rules (ii) and (iii) should be adopted.



Simple footing
FIG. 5-4



Stepped footing
FIG. 5-5

(2) **Depth of foundations:** The depth of foundations is obtained by keeping in view the following rules:

- (i) As a general rule, all the shallow foundations should be taken to a minimum depth of 800 mm below natural ground level unless hard soil is available within 800 mm.
- (ii) The total load to be transferred to the soil per square metre can be worked out and after the study of the results of the trial pits, the foundations should be taken to such a depth at which the soil has allowable bearing capacity greater than this value.
- (iii) The depth of foundations can also be obtained by drawing the lines of angles 45° and 60° as shown in fig. 5-6 and fig. 5-7 respectively.

Let

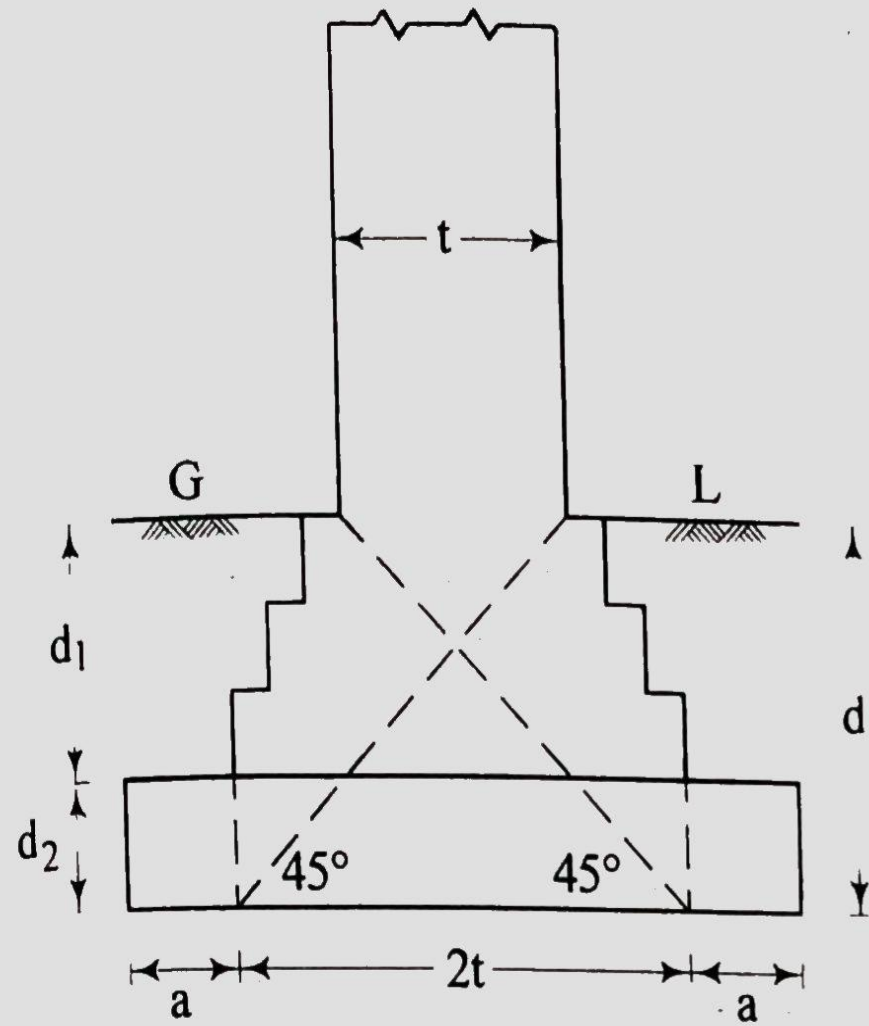
d_1 = Depth of footings

d_2 = Depth of concrete block.

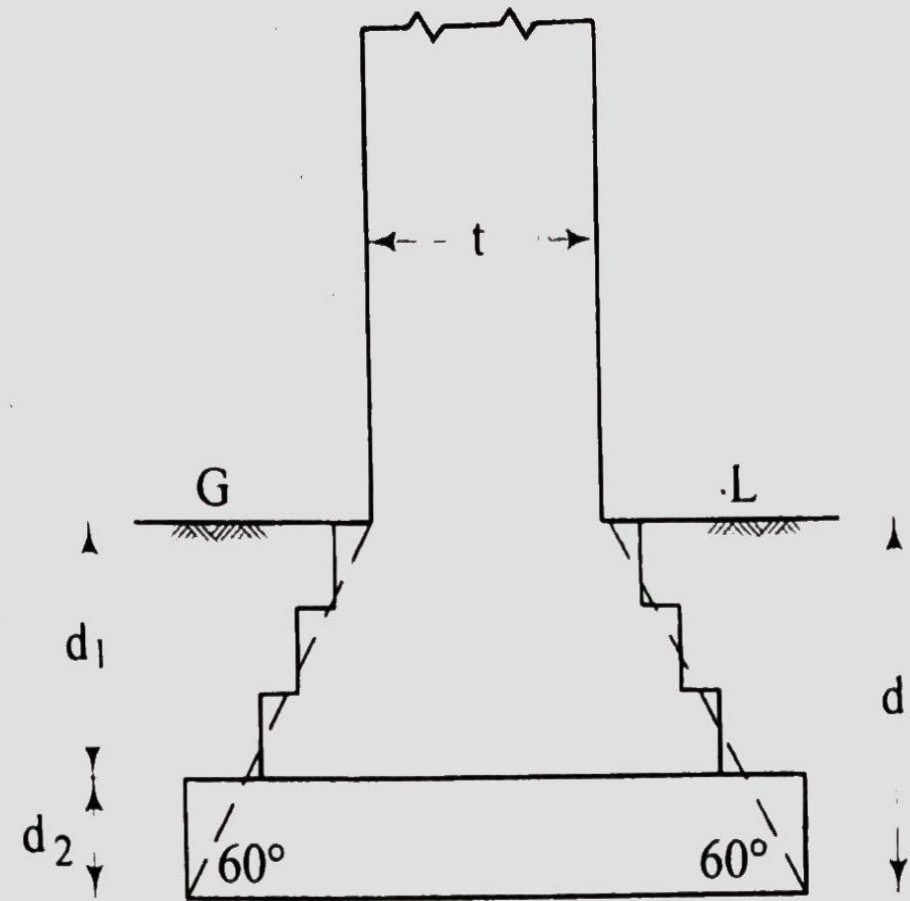
d = Total depth of foundations

Then,

$$d = d_1 + d_2.$$



Depth of foundations



Depth of foundations

- (iv) For loose soil, Rankine's formula, as given below, can be used to find the minimum depth of foundations:

$$d = \frac{p}{w} \left(\frac{1 - \sin \phi}{1 + \sin \phi} \right)^2$$

where

d = minimum depth of foundation in metres

w = weight of soil in kg/m^3 or kN/m^3

ϕ = angle of repose

p = load on soil in kg/m^2 or kN/m^2 .

The above formula is not to be used when the building to be constructed rests on hard soil. The values of angles of repose of some of the soils are given in table 5-1.

TABLE 5-1
ANGLES OF REPOSE OF VARIOUS SOILS

No.	Type of soil	Angle of repose in degrees
1.	Loose earth	30 to 45
2.	Compact earth	50
3.	Dry sand	25 to 35
4.	Moist sand	30 to 45
5.	Wet sand	15 to 30
6.	Clay	25 to 45
7.	Gravel	30 to 40
8.	Ashes	40
9.	Gravel and sand	25 to 40

- (v) For finding out the depth of concrete block, the following formula can be used:

(a) Depth of concrete block in cm = $\frac{1}{58} \sqrt{\frac{pa^2}{m}}$

(b) Depth of concrete block in cm = $\frac{5}{6} t$.

Deep foundations

Types of Deep foundations:

1. Deep strip, rectangular or square footings
2. Pile foundation
3. Pier foundation or drilled caisson foundation
4. Well foundation or caissons

Deep strip, Rectangular or square footings are generally deep foundations.

a) Pile foundation:

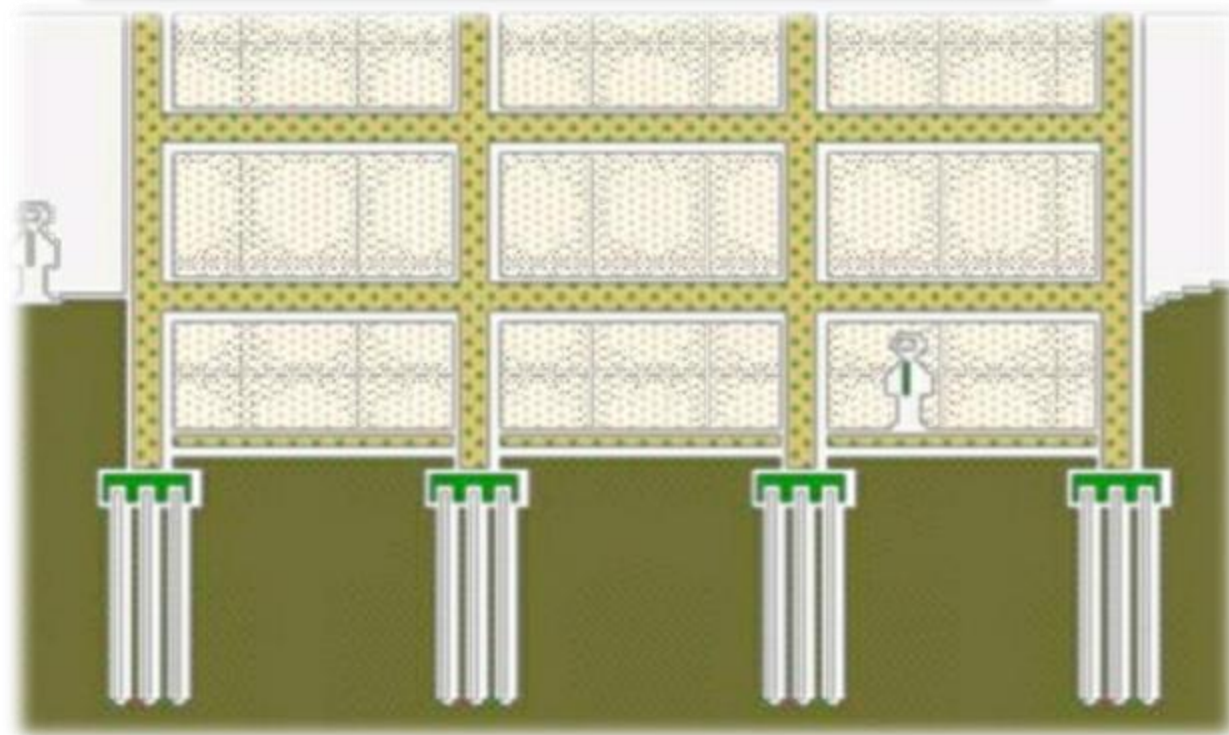
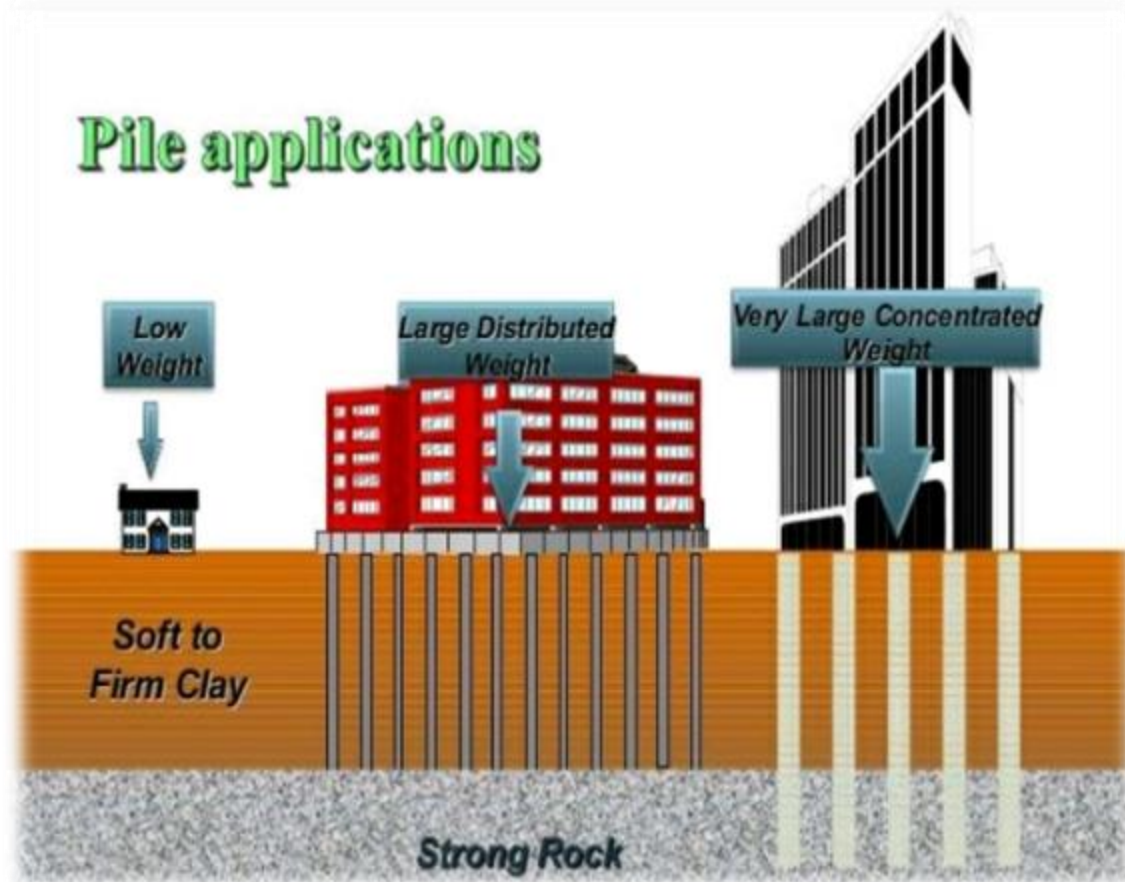
It is deep foundation where the loads are taken to a low level by means of vertical members which may be of timber, concrete or steel

It is adopted when loading is uneven and no firm bearing strata exists at reasonable depths.

When a firm bearing strata does not exist but at such depths, strip or spread footing is uneconomical, it is used.

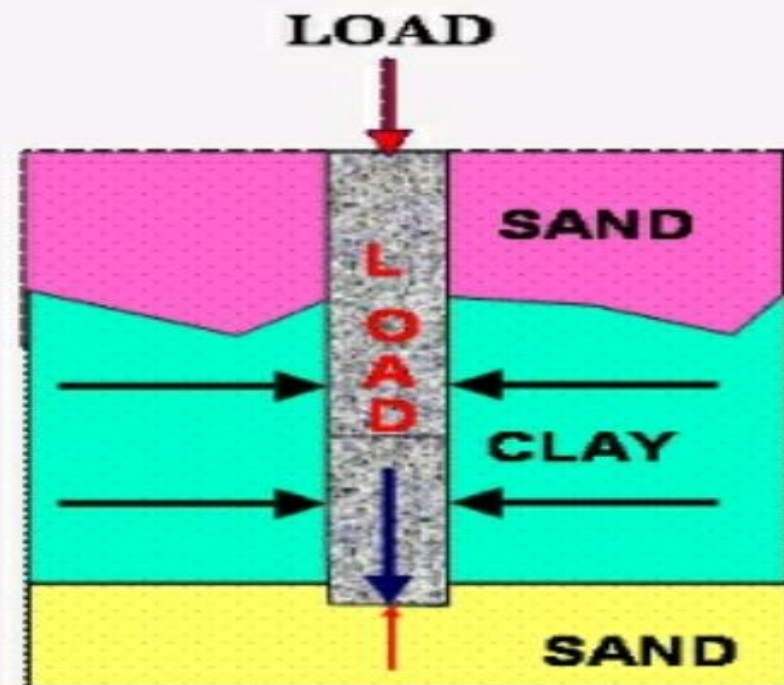
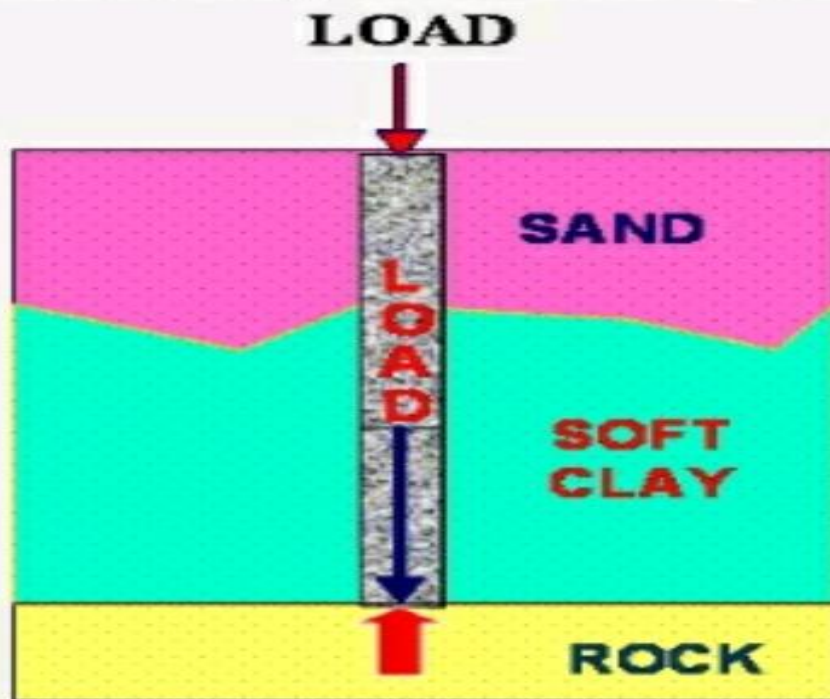
When pumping of subsoil water would be too costly it is used.

Pile applications



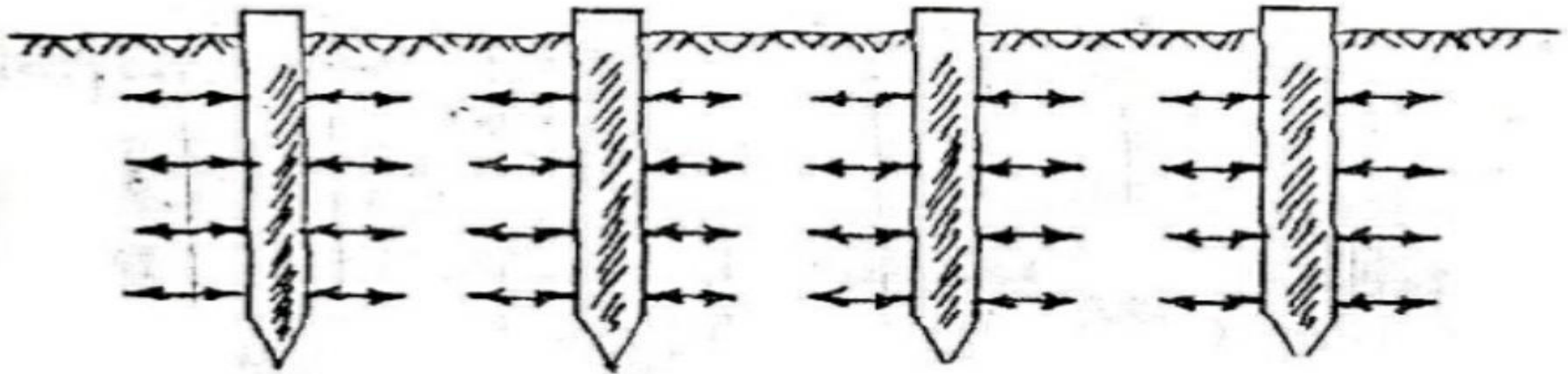
End bearing piles

- If the piles are driven into the ground until a hard stratum is reached and the piles act as a pillars supporting the super structure and transmitting the load to the hard ground.



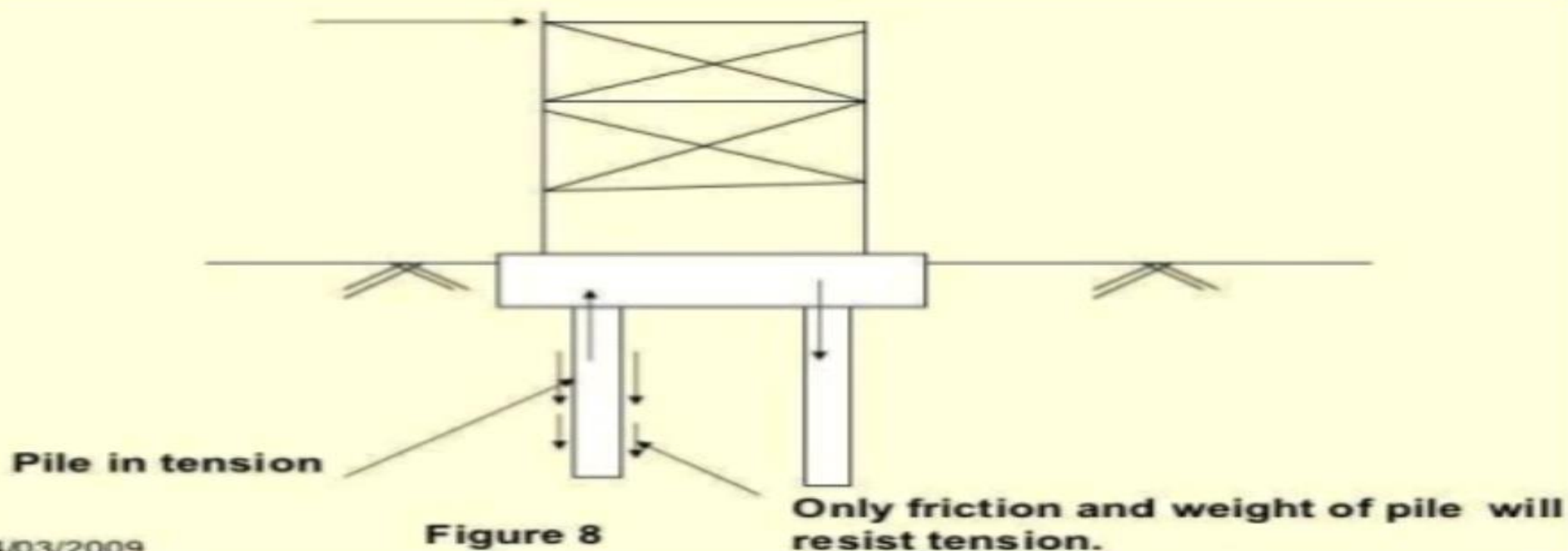
COMPACTION PILE

- Compaction piles are used to compact loose granular soil, thus increasing their bearing capacity. The compaction piles themselves don't carry load. The pile tube, driven to compact the soil, is gradually taken out and sand is filled in its place thus forming a 'sand pile'.

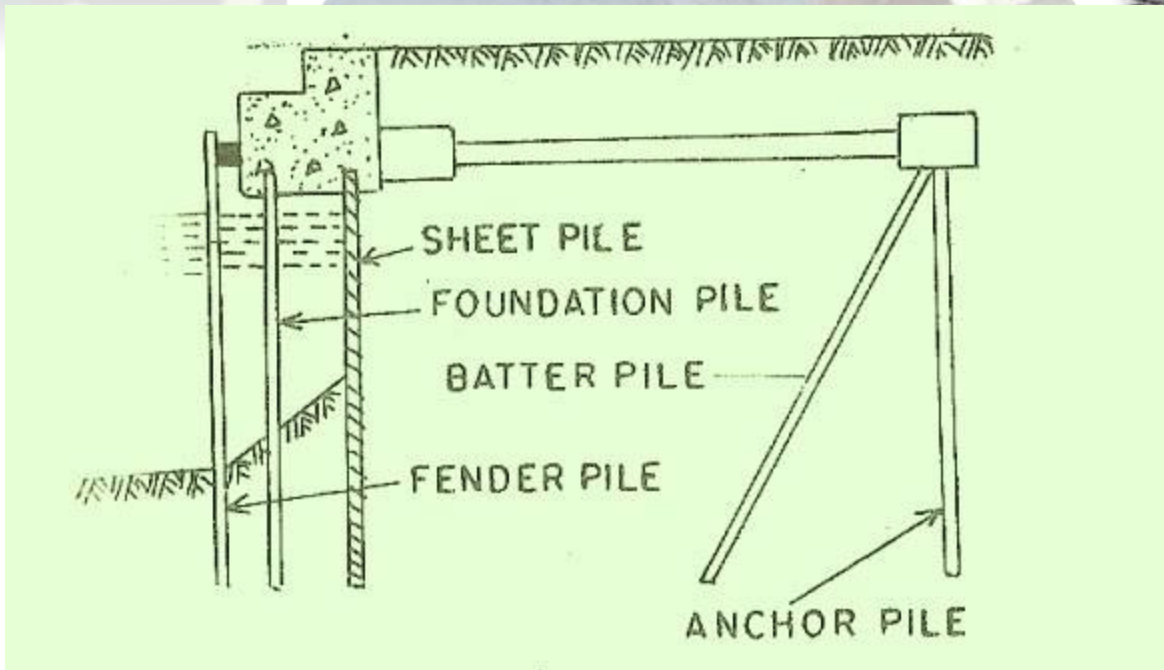


TENSION PILE

- Tension piles or uplift piles- Anchor down the structure subjected to uplift due to hydrostatic pressure or due to overturning moment.



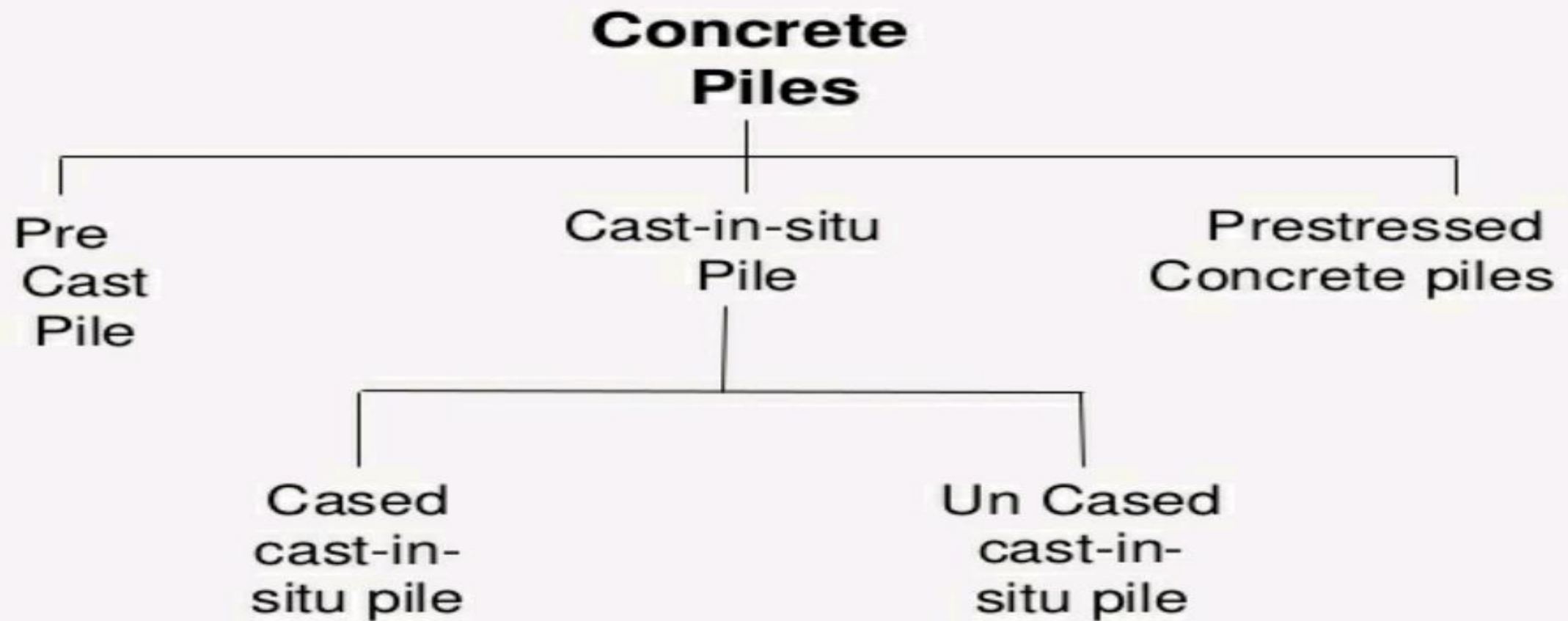
- **Fender piles-** Used to *Protect water front structures against the impact* from ships or other floating objects.
- **Sheet piles-** Used as *impervious cutoff to reduce seepage and uplift* under hydraulic structures.
- **Batter piles-** Used to *resist large horizontal or inclined forces*.
- **Anchor piles-** *Provide anchorage against horizontal* pull from sheet piles or other pulling forces.



CLASSIFICATION OF PILES (BASED ON MATERIAL)



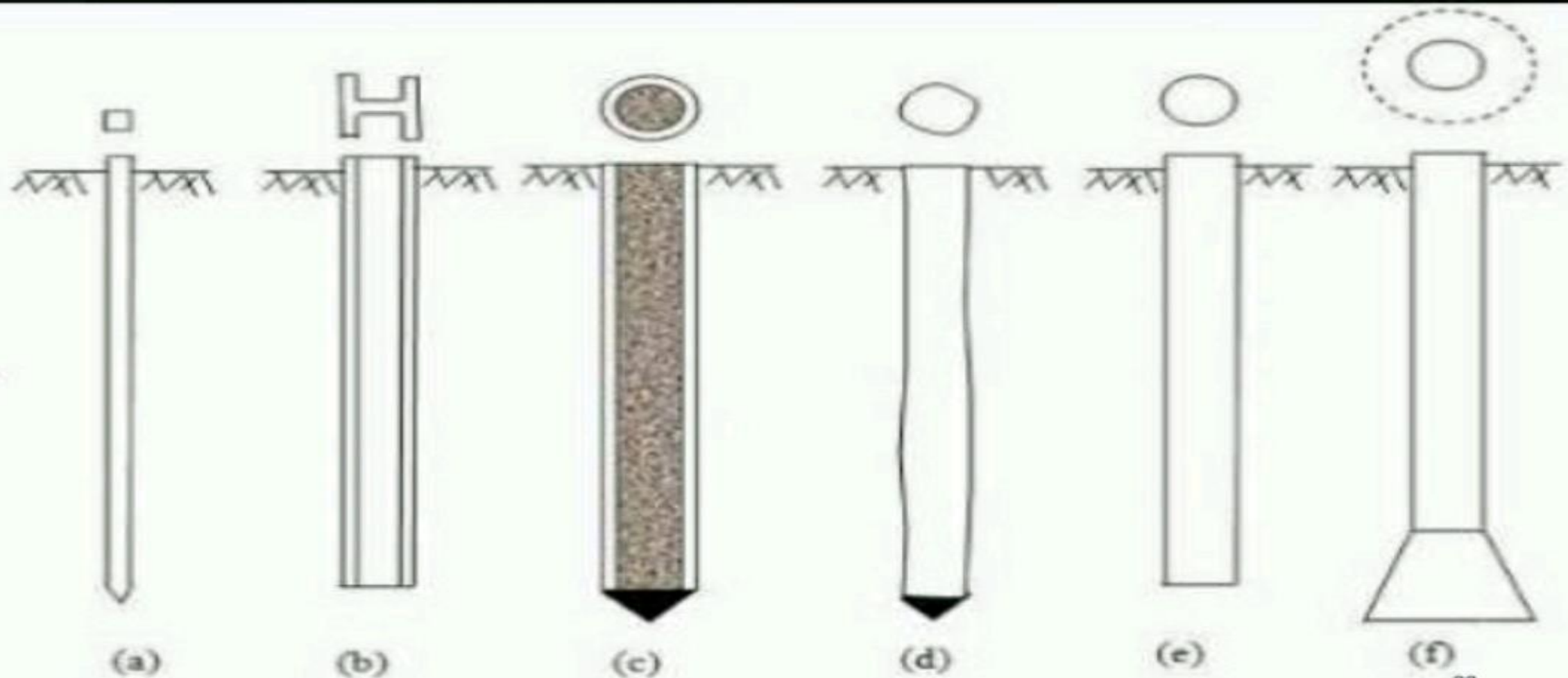
CONCRETE PILE



1. PRE CAST CONCRETE PILE

- **PRE-CAST CONCRETE PILES**
- The precast concrete piles are generally used for maximum design load of about **80 tonnes**. They must be reinforced to withstand handling stresses.
- They require space for casting and storage, more time to set and curing before installation and heavy machine are required for handling purpose and driving.
- These piles require heavy pile driving machinery which is mechanically operated.
- The size of pile may vary from 30cm to 50cm in cross-sectional dimension, and up to 20m length or more in length.
- Reinforcement may include longitudinal steel bars of 20mm to 40mm in diameter, 4 to 8 nos. with lateral tie 5 to 10mm wire spaced at 10cm c/c for top and bottom 1m length and 30cm c/c for the middle length.
- A cast steel shoe, properly secured to pile by mild steel straps, is provided at its lower end. To protect the pile and help in penetrating into hard strata during driving.

Various shape of precast pile



2.CAST-IN-SITU CONCRETE PILE

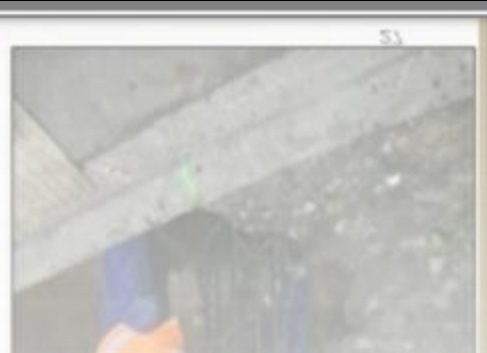
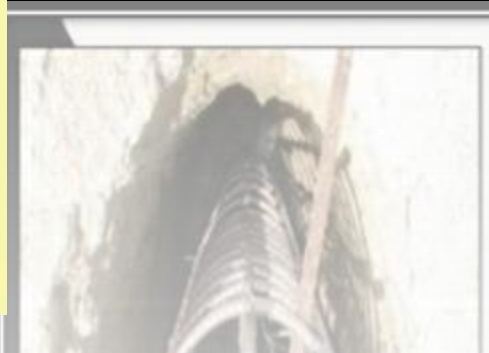
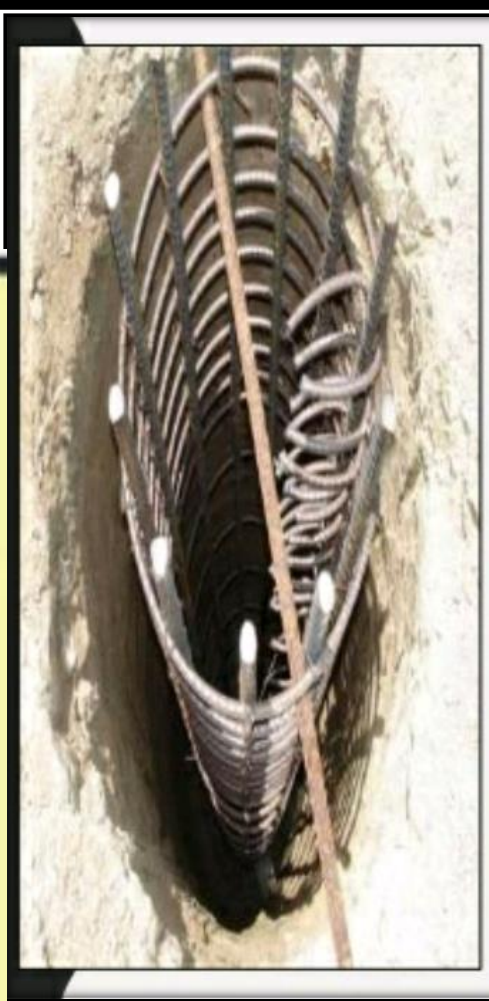
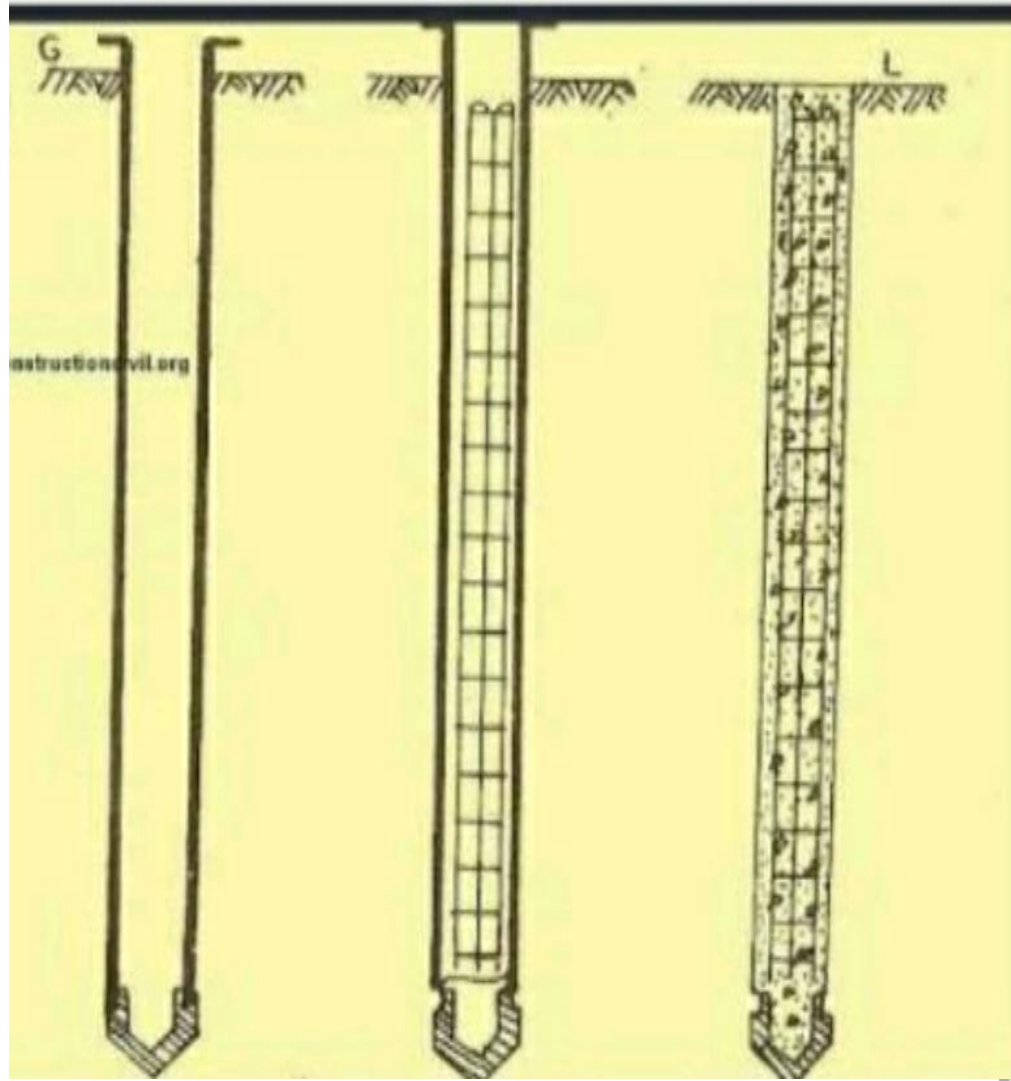
Cast-in-situ Concrete Piles

Cased

- Raymond pile
- Mac Arthur Pile
- Mono tube Pile
- Swage piles
- BSP base driven pile
- Button bottom piles

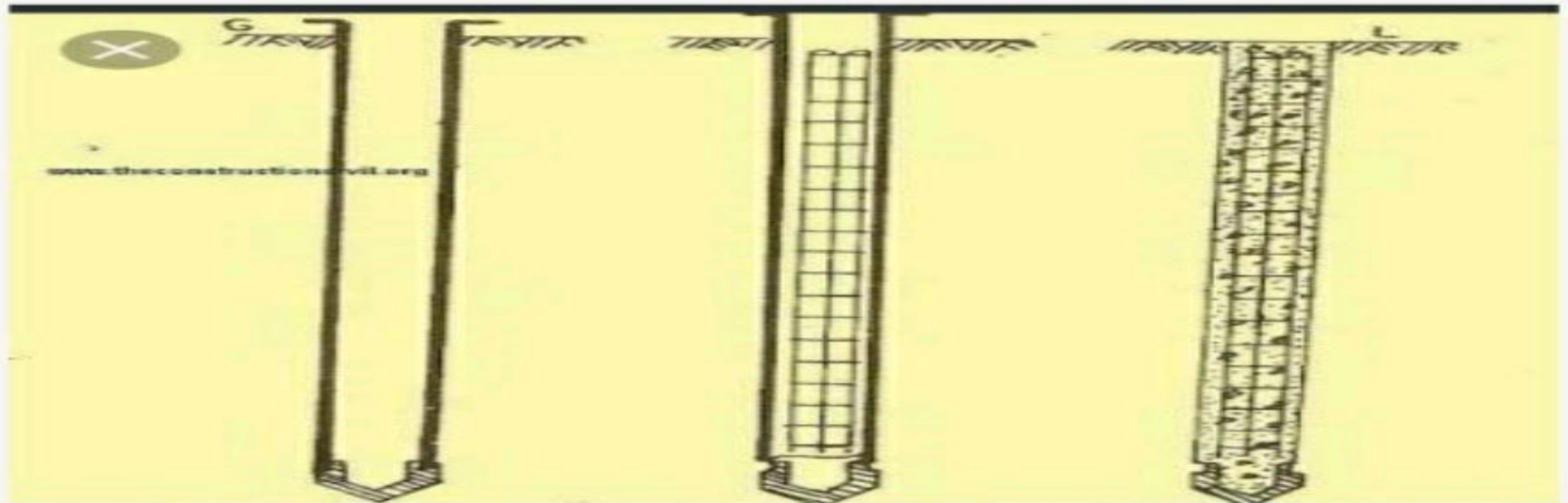
Uncased

- Simplex pile
- Franki Pile
- Vibro pile
- Pressure pile
- Pedestal pile



Cast-in-situ concrete piles

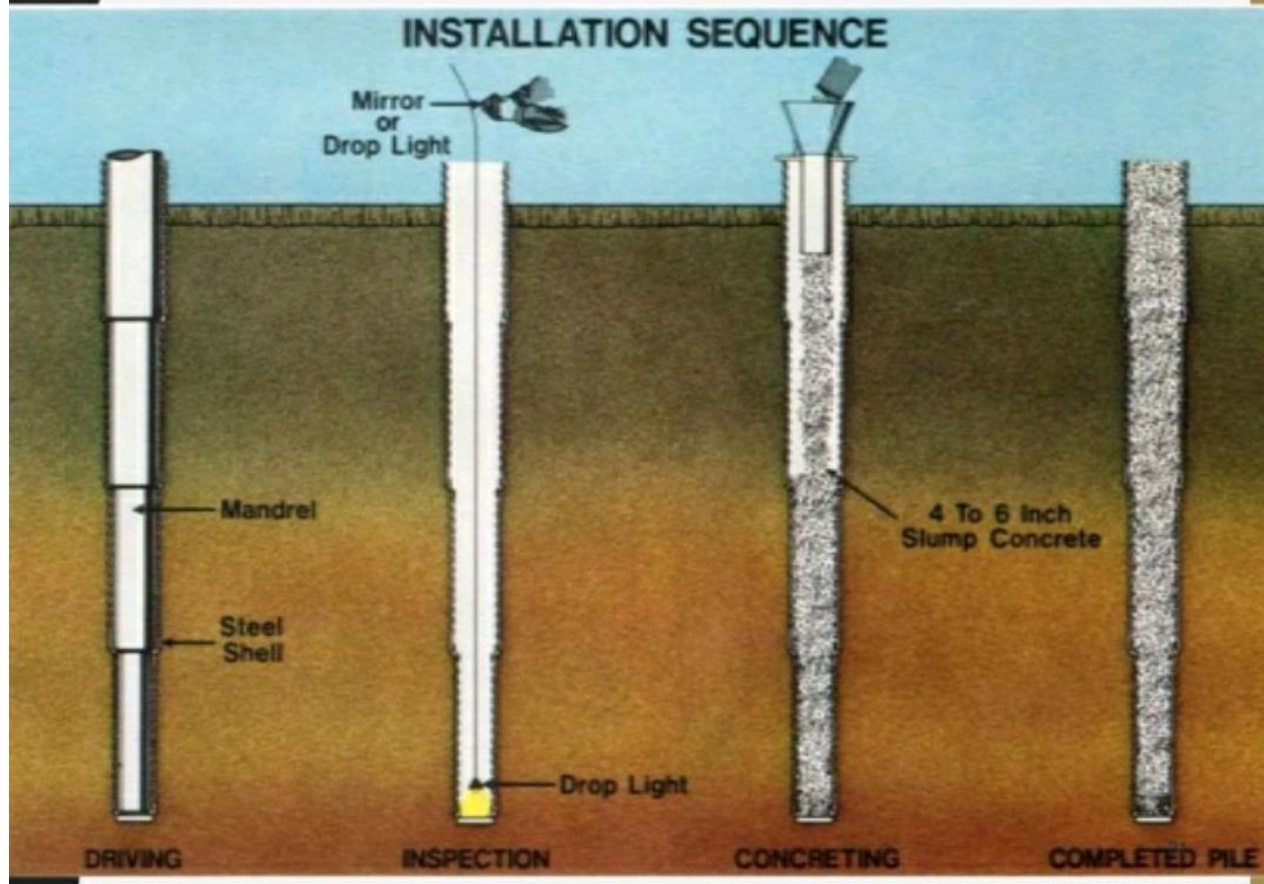
- In this type of concrete piles, a bore is dug into the ground by inserting. This bore is then filled with cement concrete after placing reinforcement, if any.



RAYMOND PILE

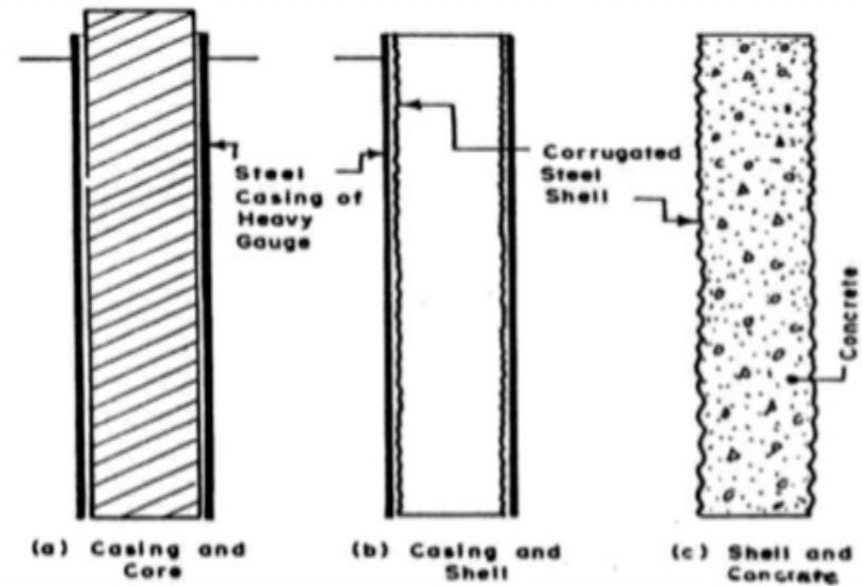
- (RAYMOND STANDARD CONCRETE PILE) is used primarily as a friction pipe. It is uniform heavy taper of 1in30 result in short piles for equal driving resistance or higher driving resistance for equal lengths, than piles of lesser or no taper.
- Length of piles varies from 6 to 12m. diameter of piles vary from 40 to 60cm at top and 20 to 30 at bottom.
- The shell is driven into the ground with a collapsible steel core in it having the same taper.
- When the pile is driven to desired depth the core is mechanically collapsed and withdrawn, leaving the shell inside the ground.
- Shell is inspected internally by using the flash or drop light.
- Shell is gradually filled with concrete up to the top.

RAYMOND PILE INSTALLATION



MAC-ARTHUR PILES

shaped into a series of parallel ridges and grooves so as to give added rigidity and strength.



MAC-ARTHUR PILES

- This pile is of uniform diameter, best example on non-taper pile.
- It used extra steel casing heavy gauge in driving pile.
- Steel casing with central core is driven into ground.
- After reaching the desired depth, core is withdrawn and shell is placed in casing.
- After that concrete is placed in the shell, by gradually compacting it, and withdrawing steel casing.
- These piles are used in place where the driving soil is very hard and it is designed to kept water tight before filling the concrete in shell.

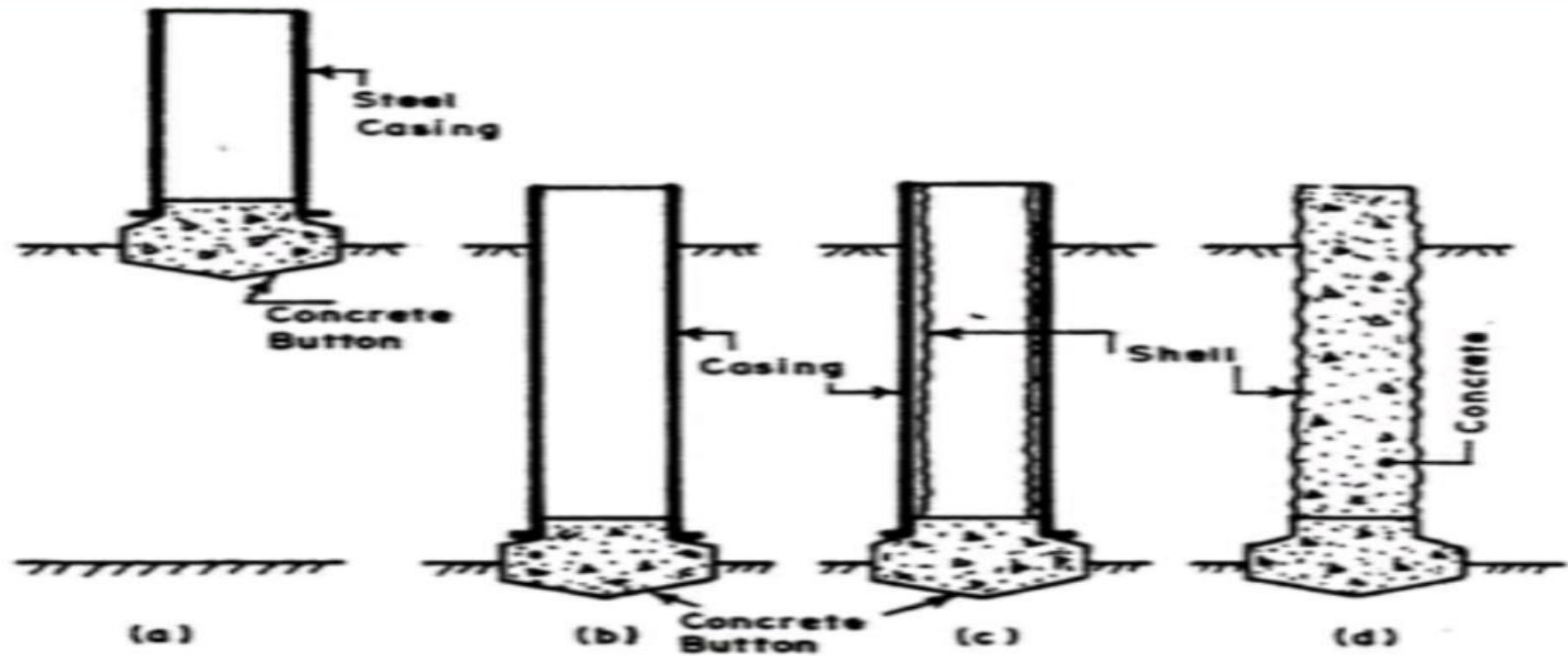
SWAGE PILES

- Swage piles are used with advantage in some soils where the driving is very hard or where it is desired to leave water tight shell, for some time before filling the concrete.

BUTTON BOTTOM PILES

- These piles are used in locations where increase in the end bearing area is desired. The pile uses a concrete plug of shape of button. These piles have been used up to lengths of about 23 m and for loads up to 50 tonnes.

BUTTON-BOTTOM PILE

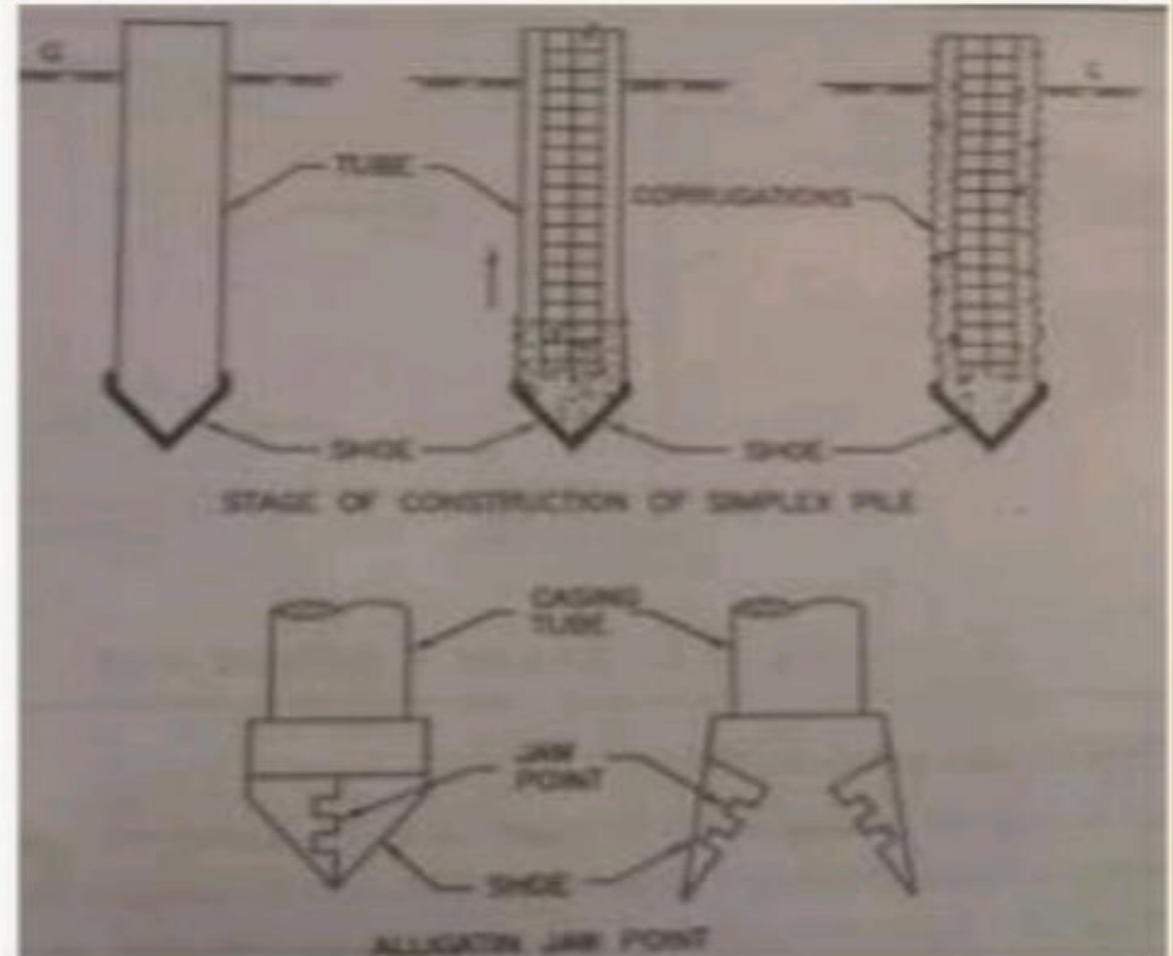


Uncased cast in situ concrete piles

- These piles are comparatively cheap, as no casing will be left in the ground. But, great skill is required in this case to achieve the desired results.
- The common types of uncased cast in situ concrete piles are:
 1. Simplex piles
 2. Franki piles
 3. Vibro piles
 4. Pedestal piles
 5. Pressure piles

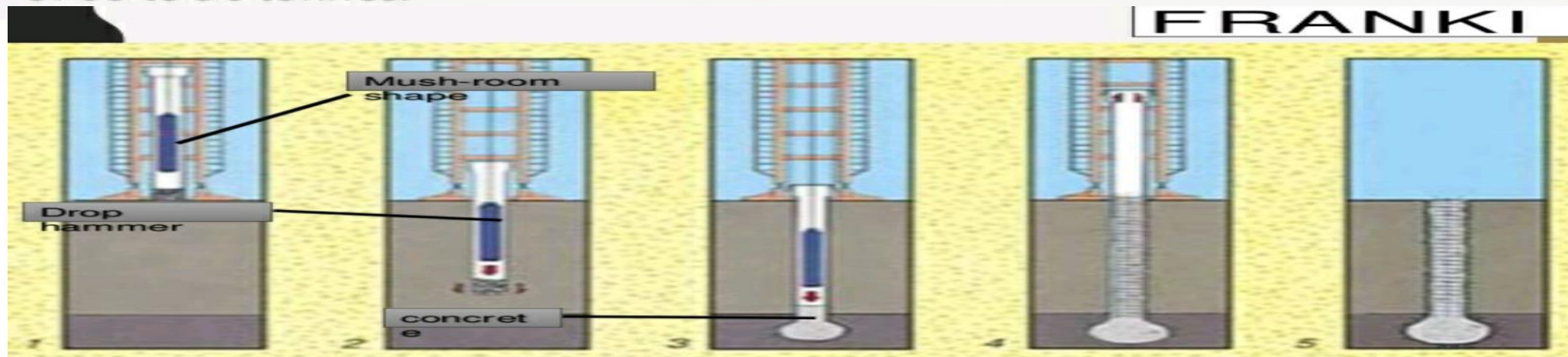
SIMPLEX PILES

- Simplex piles can be driven through soft or hard soils.
- In this type of piles a steel tube fitted with a cast iron shoe is driven into the ground up to the desired depth.
- Reinforcement if necessary is put inside the tube concrete is then poured into the tube and the tube is slowly withdrawn concrete being tamped leaving behind the cast iron shoe.



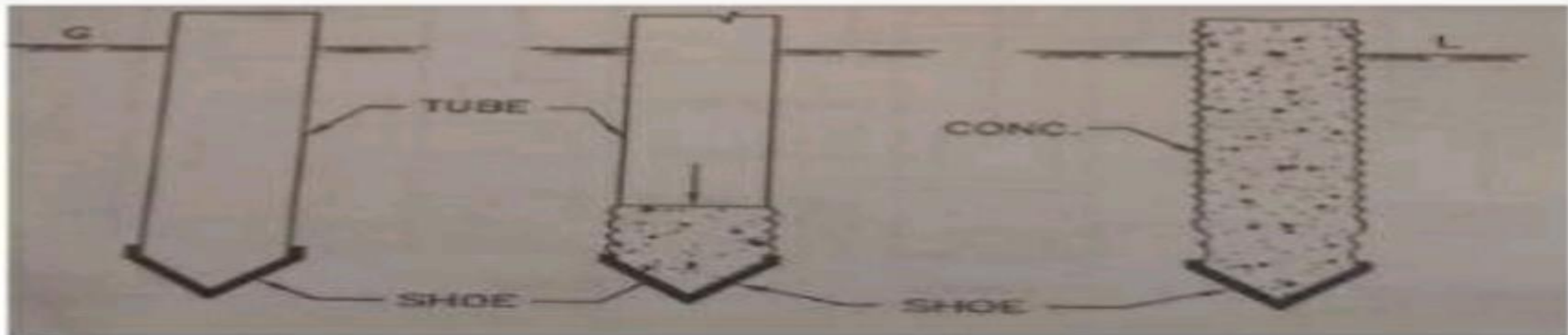
FRANKI PILES

- In this type of pile a plug of dry concrete gravel is formed on the ground by heavy removable pipe shell. A diesel operated drop hammer of 20 to 30 KN weight is driven on the concrete plug.
- When the tube has reduced the desired depth the tube is held in position by cables and the hammer is applied to the concrete plug forcing it down and outward.
- In the next stage the shaft is formed by introducing successive charges of concrete ramming each in turn and withdrawn the casing gradually about 300mm at a time.
- The pile diameter in franki piles vary from 50cm to 60cm while the enlarged base may have a diameter of about 90cm. The pile has a load carrying capacity of 60 to 90 tonnes.



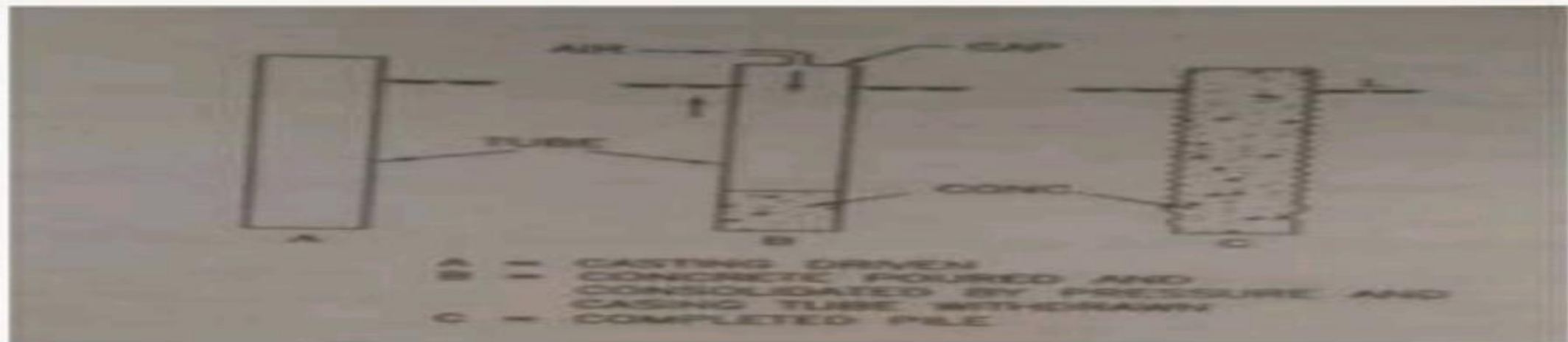
VIBRO PILES

- These pile are used where the ground is soft thus offering little frictional resistance to the flow of concrete. Both standard and expanded piles are formed by the vibro-process.
- These piles are formed by driven a steel tube and shoe filling with concrete and withdrawing the steel tube.
- Standard vibro piles are made in size of 35,45,50cm diameter for loads of 60 to 70 tonnes.
- A steel tube fitted with a cast iron shoe is driven in the ground by 2 to 2.5 tonnes hammer operated by steam or compressed air delivering up to 40 blow per minute with a stroke of about 1.4m.



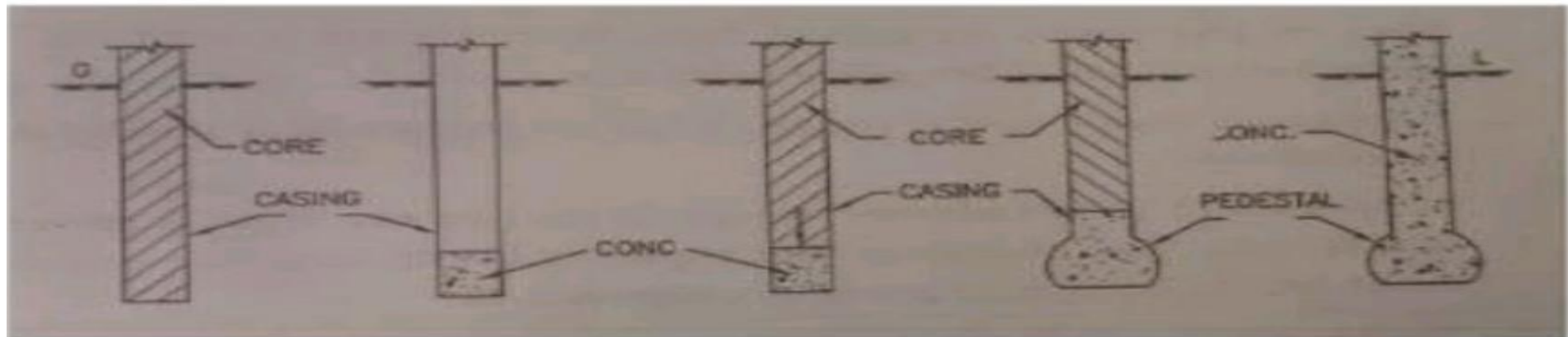
PRESSURE PILES

- These are formed with the help of a casing tube boring auger and compressed air equipment. These piles are especially suitable for those congested sites where heavy vibrations and noise are not permissible.
- A hole is bored into the ground by means of an auger and as the boring proceeds the hole is lined by a steel tube.
- When the tube reaches the required depth the boring tool is withdrawn. In the 2nd stage a layer of concrete is laid and pressure cap is provided at the top of the tube.
- The process is repeated till the pile is completed



PEDESTAL PILES

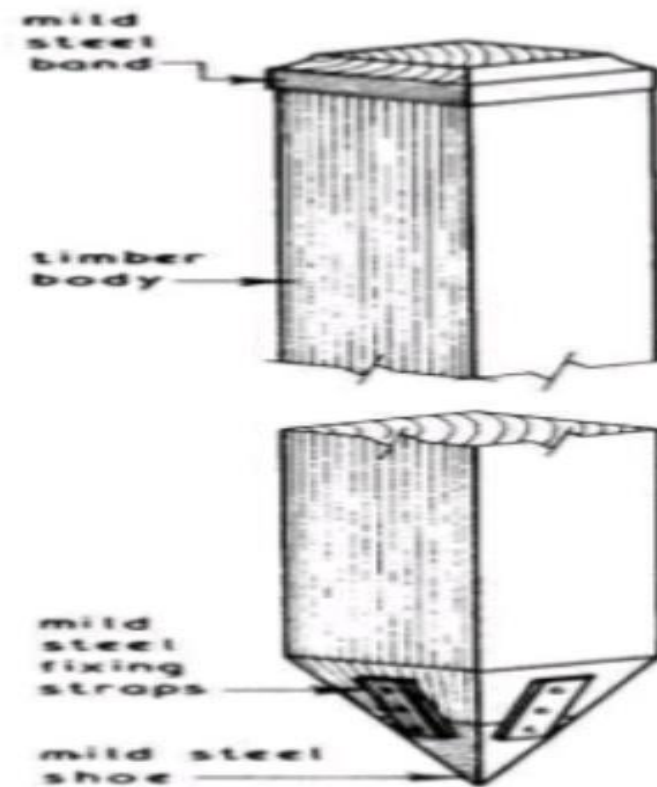
- This type of pile are used where thin bearing stratum is reached with reasonable depth.
- The core and casing are driven together into the ground till they reach the desired level.
- The core is taken out and a charge of concrete is placed in the tube.
- The core is again placed in the casing to rest on the of poured concrete. Pressure is applied on the concrete through the core and as the same time the casing is withdrawn.
- The process is repeated till the casing is completely removed.



TIMBER PILE

- Timber piles are made of tree trunks driven with small end as a point
- They may be circular or square.
- They are 30 to 50 cm in diameter with a length not exceeding 20 times its top width.
- At the bottom, a cast-iron shoe is provided and the top a steel plate is fixed.
- They have small bearing capacity and are not permanent unless treated.

Typical Example -



STEEL PILE

Steel piles are useful where driving conditions are difficult and other types of piles are not suitable. Usually used for building and bridge foundations.

The piles are in form of I, H sections and steel pipe piles.

They can be used for:

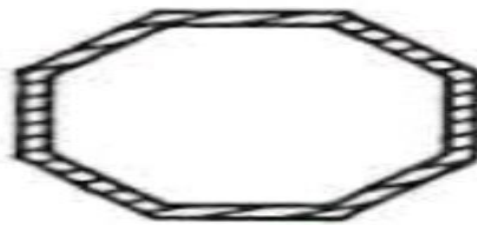
1. Foundation piles
2. Sheet piles
3. Superstructure columns

- **Steel I and H Piles**

- ▶ Steel H piles are similar to I-beam except that the cross-section is generally heavier and the flange width and beam height is nearly the same.



H pile



box pile

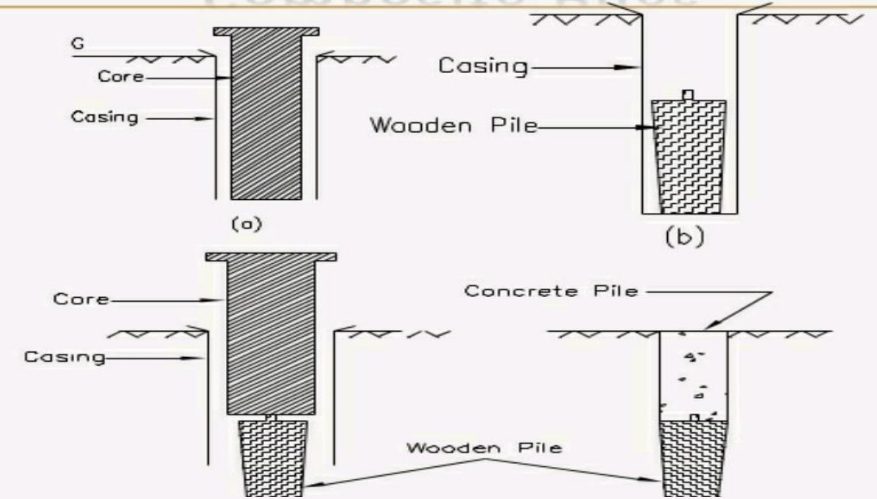


tube pile

Composite Piles

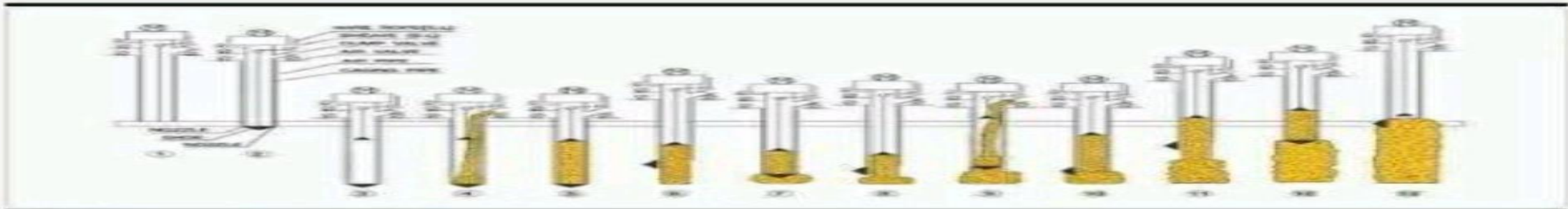
- Piles of two different materials are driven one over the other, so as to enable them to act together to perform the function of a single pile.
- This type of composite pile is used with the object of achieving economy in the cost of piling work.

Composite Piles



Sand piles:

- These piles are formed by making holes in the ground and then filling them with sand. If sand is kept confined, it possesses great crushing strength and becomes incompressible.
- A bore hole of required diameter, then filled with sand and it is well rammed. The top of sand pile is filled with concrete to prevent the sand ejecting upwards due to lateral pressure.



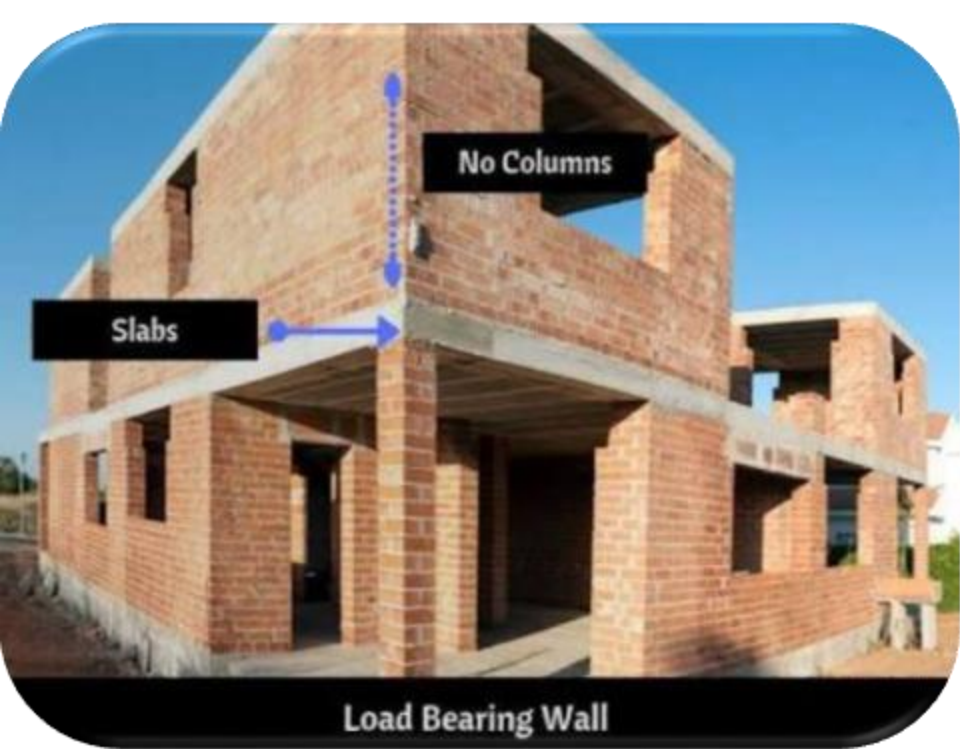
Classification based on method of installation

- ▶ **Driven piles:**

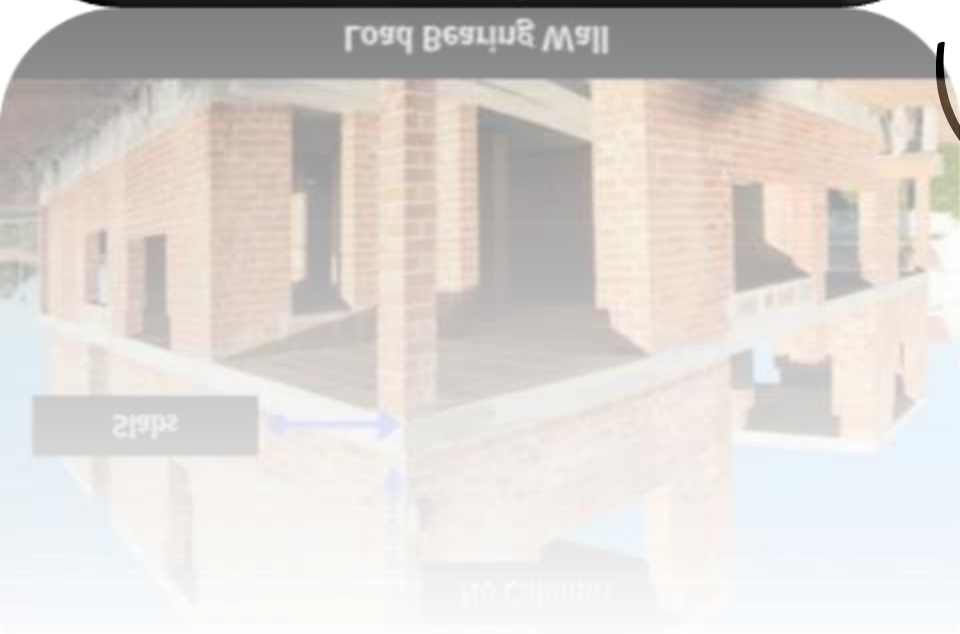
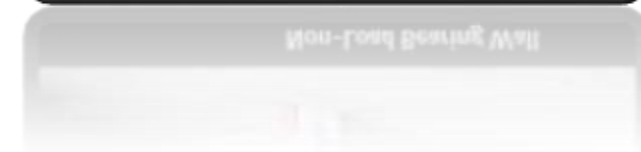
- ▶ These piles are driven into the ground by applying blows with a heavy hammer on their tops.
- ▶ Timber, steel and precast concrete piles are installed by driving, which may be driven into position either vertically or at an inclination.

- ▶ **Driven and cast-in-situ piles:**

- ▶ These piles are formed by driving a casing with a closed bottom end into the soil.
- ▶ The casing is later filled with concrete.
- ▶ The casing may or may not be withdrawn, it is called uncased pile, and if not withdrawn, it is called cased pile.



Load Bearing Wall



Load Bearing Wall

CHAPTER 3 (CONSTRUCTION) TECHNOLOGY) WALL & MASONARY WORK



Walls & Masonry Works

3.1 Purpose of walls

3.2 Classification of walls — load bearing, non-load bearing walls, retaining walls.

3.3 Classification of walls as per materials of construction: brick, stone, reinforced brick, reinforced concrete, precast, hollow and solid concrete block and composite masonry walls (Concept Only).

3.4 Partition Walls : Suitability and uses of brick and wooden partition walls

3.5 Brick masonry : Definition of different terms

3.6 Bond — meaning and necessity: English bond for half brick thick walls. T, X and right angled corner junctions. Thickness for half brick square pillars in English bond

3.7 Stone Masonry :

3.8 Glossary of terms —String course, corbel, cornice, block-in-course, grouting, mouldings, templates, throating, through stones, parapet, coping, pilaster and buttress

3.1 Purpose of Wall :-

The **purposes of walls** in buildings are to support roofs, floors and ceilings; to enclose a space as part of the building envelope along with a roof to give buildings form; and to provide shelter and security.

Functions of Wall:-

1. STRENGTH

A wall should be strong enough to take up the loads safely due to its own weight, super imposed loads and lateral pressure such as wind.

2. STABILITY

It should be stable against overturning by lateral forces (due to wind load) and buckling caused by excessive slenderness.

3. WEATHER RESISTANCE

All the external walls, whether of load bearing or panel construction, should provide adequate resistance to rain, sun and wind penetration.

4. FIRE RESISTANCE

The walls should offer sufficient resistance to fire, as they behave as vertical barriers for spread of fire in the horizontal direction. So the walls should be made of such a material which neither ignites nor allow the spread of the fire through them.

5. HEAT INSULATION

It should be possible for walls to attain insulation against heat. For this, the walls are made either thicker, or cavity wall construction is employed. Heat insulating materials are also used in construction of walls.

6. SOUND INSULATION

The walls, both load bearing and non-load bearing, should be made of such materials and by such techniques, viz., cavity wall construction, so as to insulate building against indoor and outdoor noises.

7. PRIVACY & SECURITY

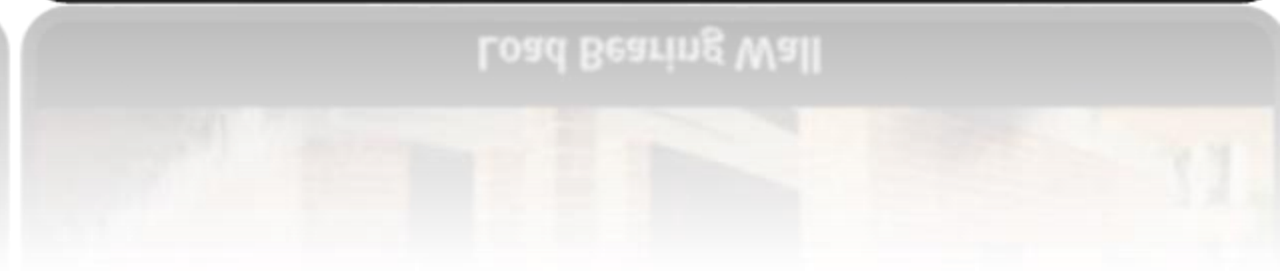
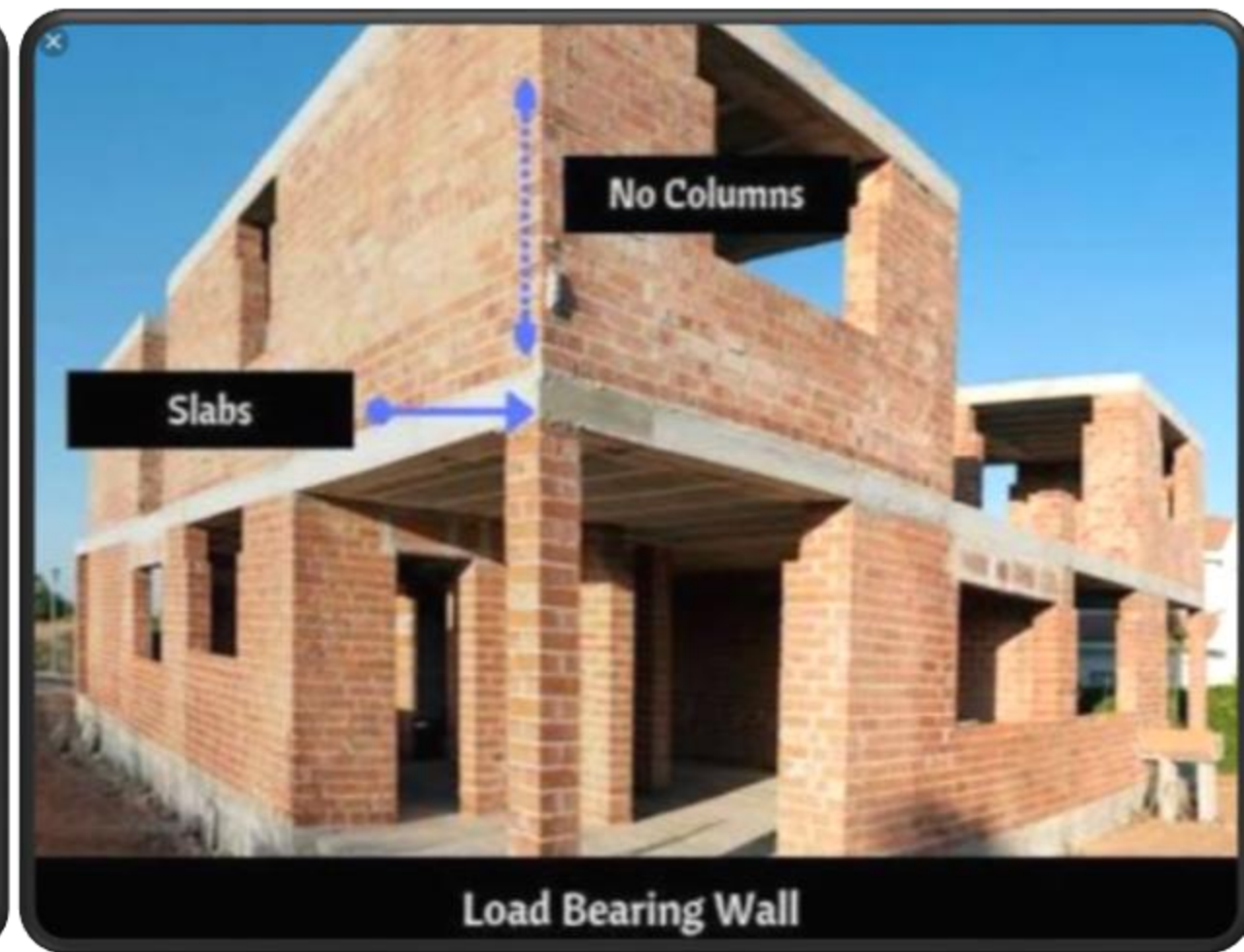
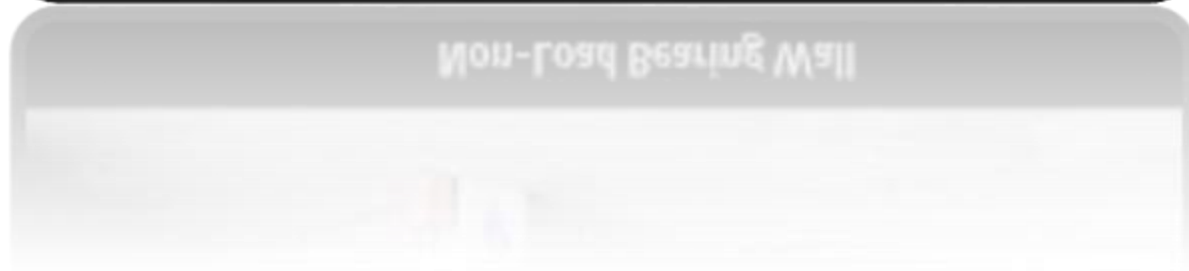
The walls, particularly external walls, should also provide sufficient privacy and afford security against burglary.

3.2 Classification of walls — load bearing, non-load bearing walls, retaining walls.

3.2.1 Load bearing Wall:-

Load bearing wall is a structural element.

- It carries the weight of a house from the roof and upper floors, all the way to the foundation. It supports structural members like beams, slab and walls on above floors above. **A wall directly above the beam is called load bearing wall.**
- It is designed to carry the vertical load. In another way, if a wall doesn't have any walls, posts or other supports directly above it, it is more likely to be a load-bearing wall.
- Load bearing walls also carry their own weight. This wall is typically over one another on each floor.
- Load bearing walls can be used as interior or exterior wall. This kind of wall will often be perpendicular to floor joists or ridge.
- Concrete is an ideal material to support these loads. The beams go directly into the concrete foundation. Load bearing walls inside the house tend to run the same direction as the ridge



3.2.2 Non load bearing wall:-

- A wall which doesn't help the structure to stand up and holds up only itself is known as a non-load bearing wall.
- It doesn't support floor roof loads above. It is a framed structure. Most of the time, They are interior walls whose purpose is to divide the structure into rooms. They are built lighter.
- One can remove any non-load bearing walls without endangering the safety of the building. Non-load bearing walls can be identified by the joists and rafters.
- They are not responsible for gravitational support for the property. It is cost effective. This wall is referred to as "curtain wall".

Types of Non-Load Bearing Wall:

- Hollow Concrete Block
- Facade Bricks
- Hollow Bricks
- Brick Walls

3.2.3 Retaining wall:-

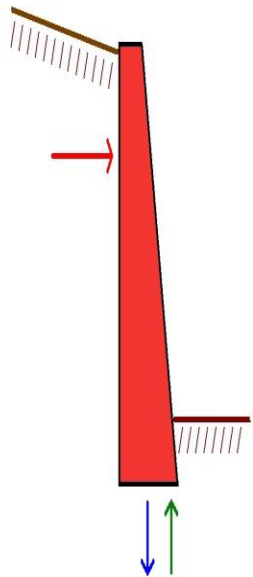
- Retaining wall is a structure that retain (holds back) any material (usually earth) and prevents it from sliding or eroding away. It is designed so that to resist the material pressure of the material that it is holding back.

Types of Retaining Wall

- An earth retaining structure can be considered to have the following types:
- Gravity Walls
 - Reinforced Gravity Walls
 - Concrete Cantilever retaining wall
 - Counter-fort / Buttressed retaining wall
 - Precast concrete Retaining wall
 - Pre-stressed retaining wall

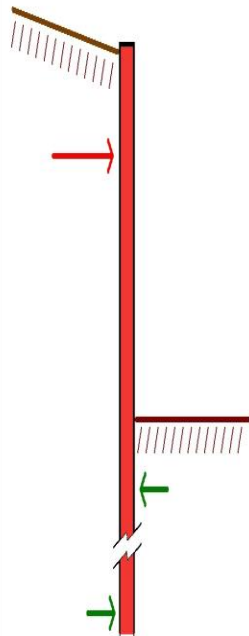
DIFFERENT TYPES OF RETAINING WALL

Gravity wall



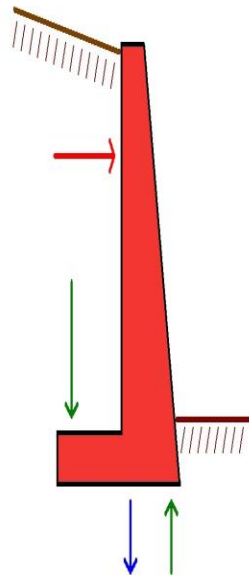
GRAVITY

Piling wall



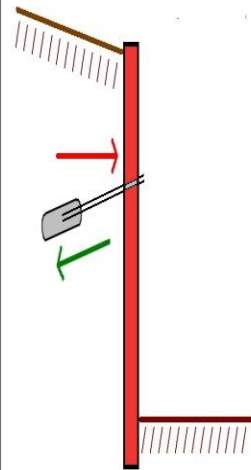
PILING

Cantilever wall

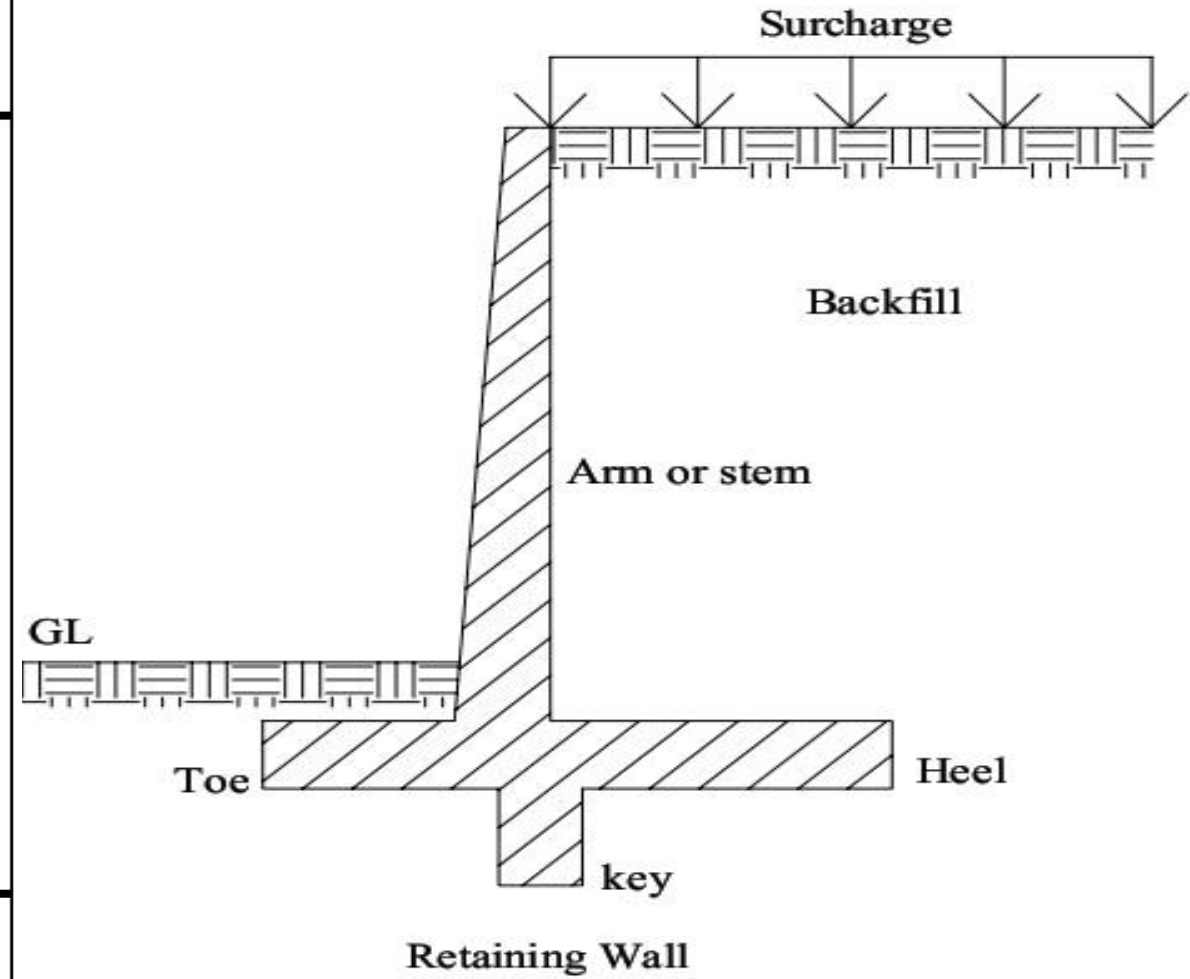


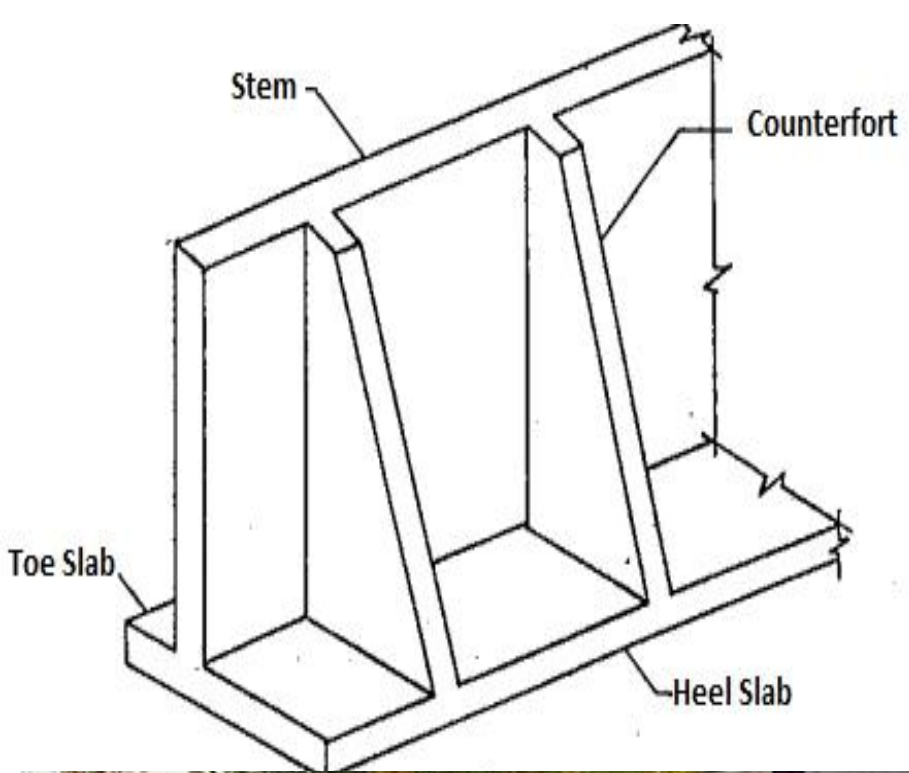
CANTILEVER

Anchored wall



ANCHORED





Gravity Retaining Wall:-

- Gravity Retaining Wall can be constructed from concrete, stone or even brick masonry. Gravity retaining walls are much thicker in section.
- Geometry of these walls also help them to maintain the stability.
- Mass concrete walls are suitable for retained heights of up to 3 m

Cantilever retaining wall

- A cantilever retaining wall is one that consists of a wall which is connected to foundation.
- A cantilever wall holds back a significant amount of soil, so it must be well engineered. They are the most common type used as retaining walls.
- Cantilever wall rest on a slab foundation. This slab foundation is also loaded by back-fill and thus the weight of the back-fill and surcharge also stabilizes the wall against overturning and sliding.

Counter-fort / Butressed retaining wall

- Counterfort walls are cantilever walls strengthened with counter forts monolithic with the back of the wall slab and base slab.
- The counter-forts act as tension stiffeners and connect the wall slab and the base to reduce the bending and shearing stresses.
- To reduce the bending moments in vertical walls of great height, counterforts are used.

3.3 Classification of walls as per materials of construction:

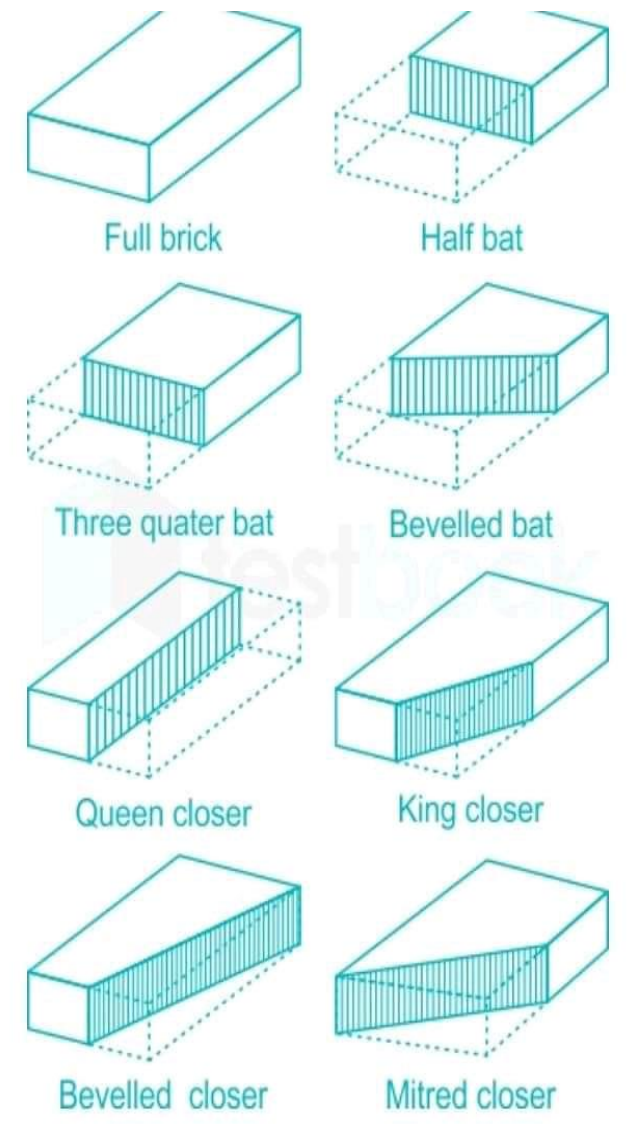
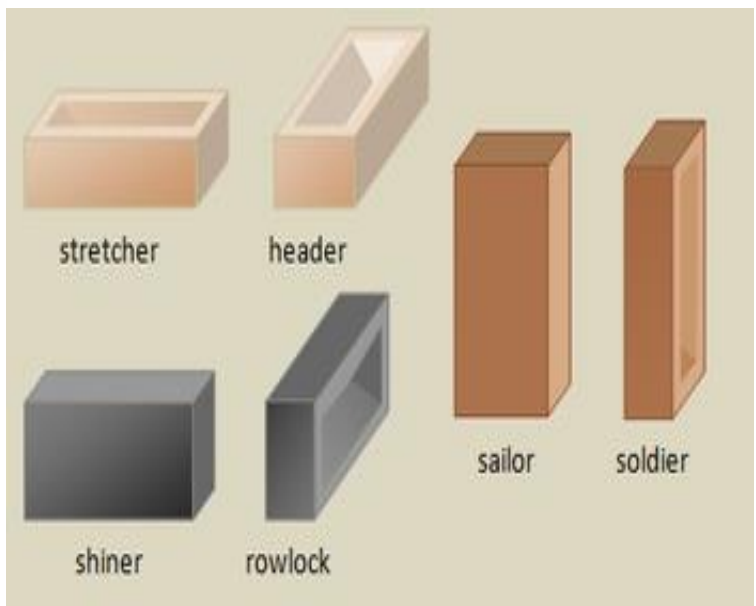
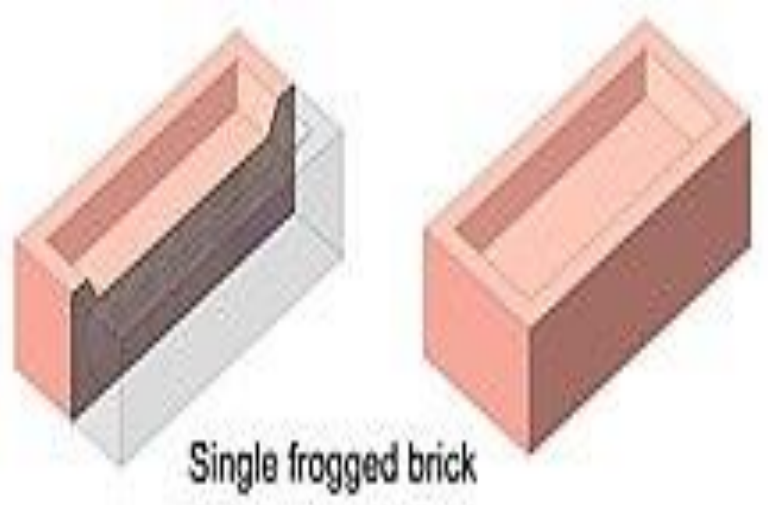
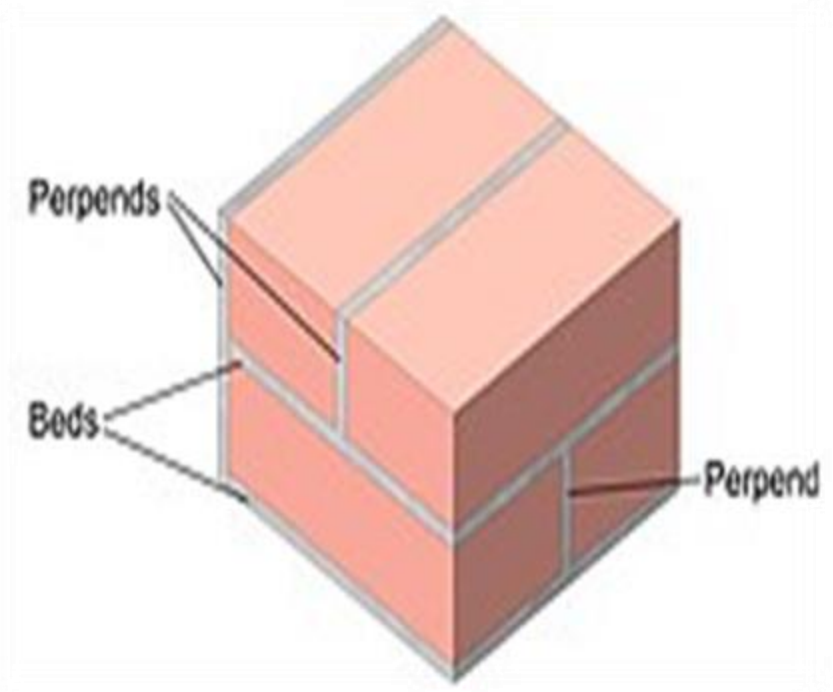
BRICK WALL:-

- Brickwork is masonry produced by a bricklayer, using bricks and mortar. Typically, rows of bricks called courses are laid on top of one another to build up a structure such as a brick wall. Bricks may be differentiated from blocks by size.

As the most common bricks are rectangular prisms, six surfaces are named as follows:

- Top and bottom surfaces are called Beds
- Ends or narrow surfaces are called Headers or header faces
- Sides or wider surfaces are called Stretchers or stretcher faces
- Mortar terminology- showing perpends and bed.
- Mortar placed between bricks is also given separate names with respect to their position. Mortar placed horizontally below or top of a brick is called a bed, and mortar Placed vertically between bricks is called a perpend.

- **Three-quarter bat, stretching** A brick cut to three-quarters of its length, and laid flat with its long, narrow side exposed.
- **Three-quarter bat**, heading A brick cut to three-quarters of its length, and laid flat with its short side exposed. Half bat A brick cut in half across its length, and laid flat.
- **Queen closer** :- A brick cut in half down its width, and laid with its smallest face exposed and standing vertically. A queen closer is often used for the purpose of creating a lap



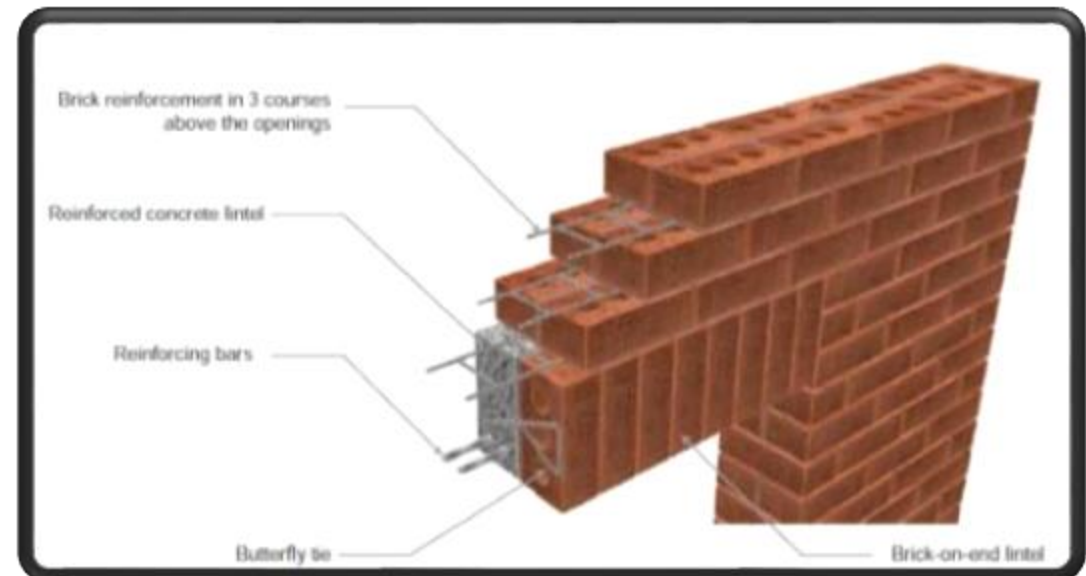
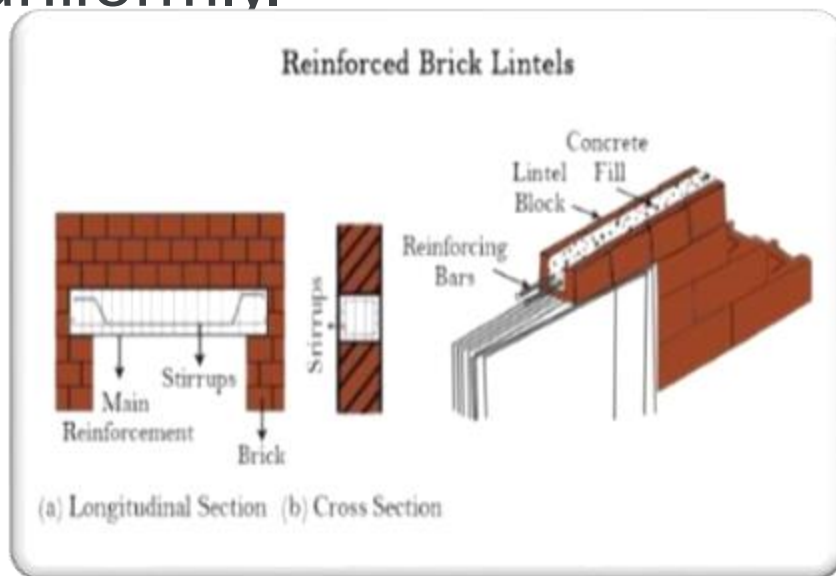
STONE WALL:-

- Stone walls are a kind of masonry construction that has been used for thousands of years. The first stone walls were constructed by farmers and primitive people by piling loose field stones into a dry stone wall



REINFORCED BRICK WALL:-

- Reinforced Brick Wall: Walls that are prone to tensile forces are needed to be reinforced, and both horizontal and vertical reinforcement is required.
- Horizontal reinforcement is provided at every third or fourth course, consists of steel mesh spread flat on the cement mortar and pressed uniformly.



REINFORCED CONCRETE WALL:-

- These wall are of 3 types
 1. Solid concrete block
 2. Hollow concrete Block
 3. Precast concrete block



The residential and commercial construction industries make wide use of a form of concrete building material known officially as a *concrete masonry unit* (CMU). These hollow-core blocks can be made of standard concrete with traditional sand and gravel aggregate held together with Portland cement. Or, they can substitute lighter-weight industrial waste materials, such as fly ash or coal cinders, for the sand and gravel aggregate, in which case they are usually known as *cinder block*

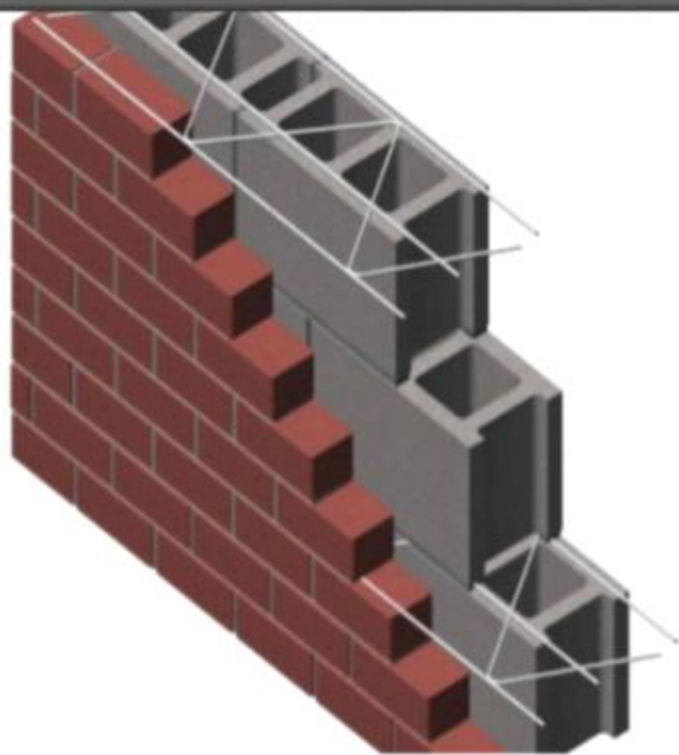


Composite Masonry Wall:-

- Composite masonry is a masonry constructed with two or more types of construction units or different types of construction materials, i.e. bricks, stones, etc.

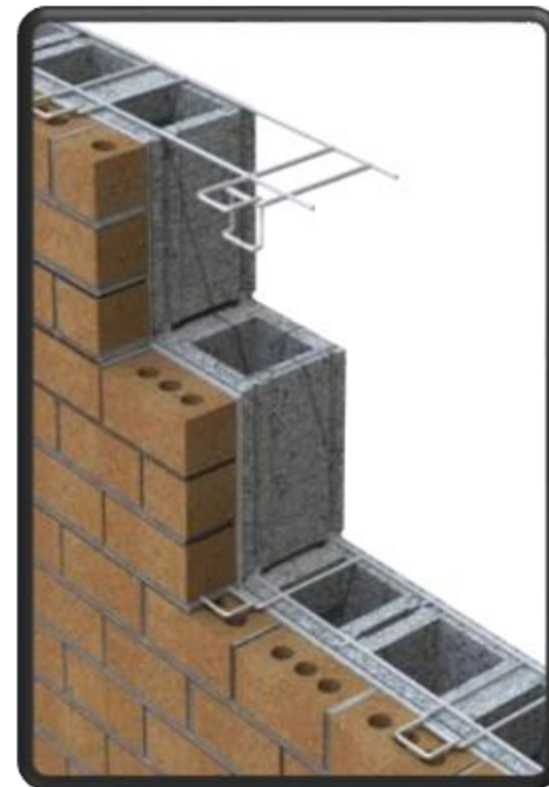
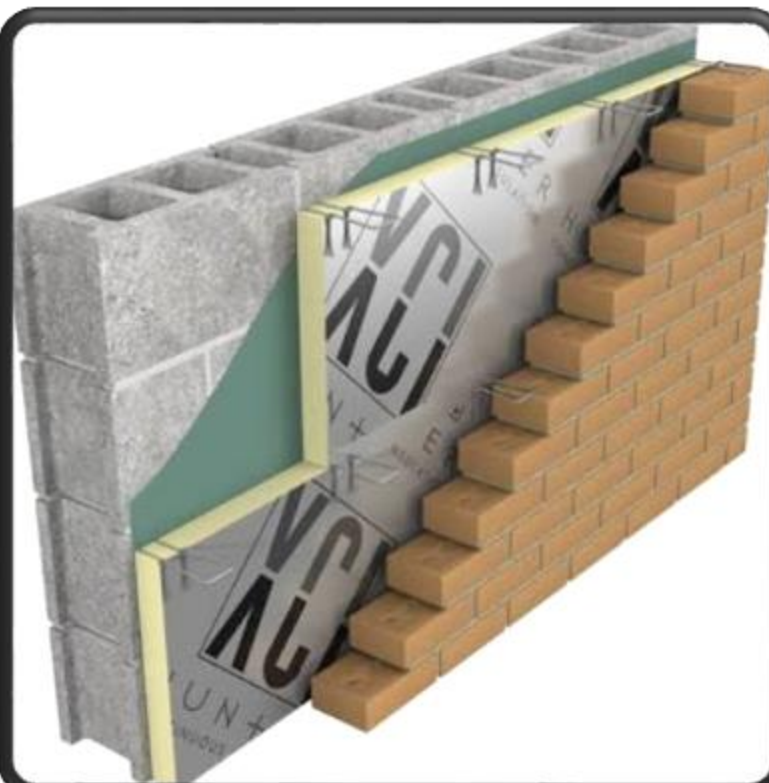
Composite masonry is adopted for the following reasons:

1. This masonry reduces the overall cost of construction.
2. It makes the structure more durable by providing better quality and good workmanship material in the faces.
3. Also, improves the appearance of the structure by concealing the inferior function.
4. It achieves optimum economy using locally available materials



COMPOSITE MASONRY

COMPOSITE MASONRY



Partition Walls : Suitability and uses of brick and wooden partition walls

- A partition wall defined as a wall or division made up of bricks, studding, glass or other such material and provided for dividing from one room to another room.
- Partition Wall can be constructed as a [load-bearing wall](#) or [non-load bearing wall](#). The load-bearing partition wall is known as the internal wall.
- These internal walls do not carry any weight. Sometimes partition wall may be folded, collapsible, or fixed type.
- Partition walls or walls can be constructed in various shapes like – thin, light, or thick, heavy, etc. Mainly, these walls' requirements are based on building materials and design

Requirements of a Good Partition Wall:

- Thin in cross-section so that maximum floor area can be utilized.
- Provide adequate privacy in rooms both in respect of sight and sound.
- Constructed from light, sound, uniform, homogeneous, durable and sound insulated materials.
- Simple in nature, easy and economical in construction having proper coherence with the type of building structure.
- Offer sufficient resistance against fire, heat, dampness, white ant or fungus, etc.
- Rigid enough to take the vibrations caused due to loads.
- Strong enough to support sanitary fittings and heavy fixtures.

Brick Partition Wall

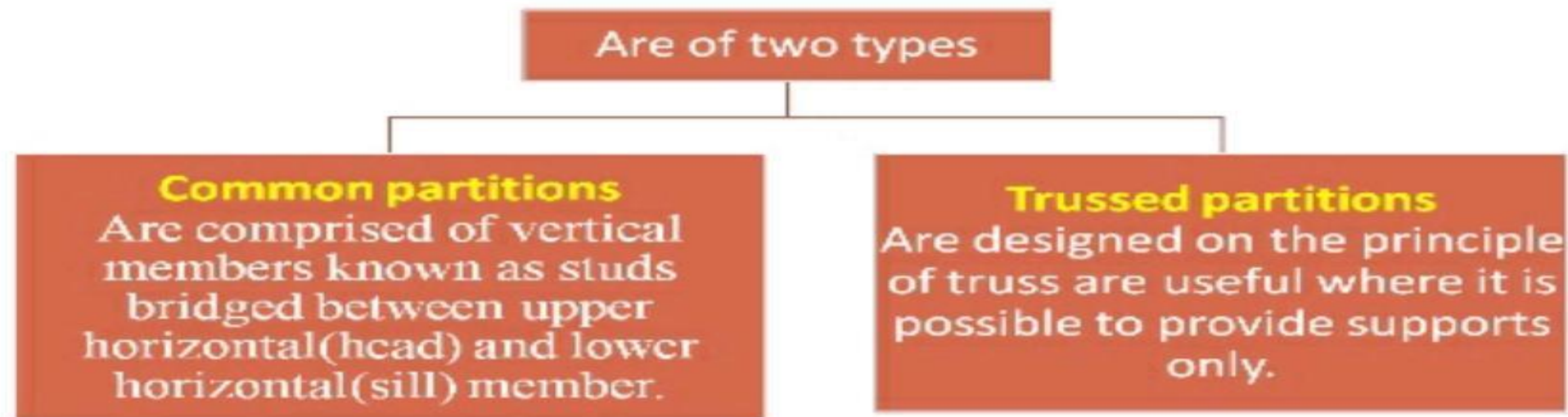
- Brick walls are known for their stretcher bond as the wall is plastered at both sides. Raw materials are used to make this wall, which makes it economical. They tend to be hard, durable, reusable, and recyclable.
- The height of the plain brick partition of half brick stiffness is not more than 2m

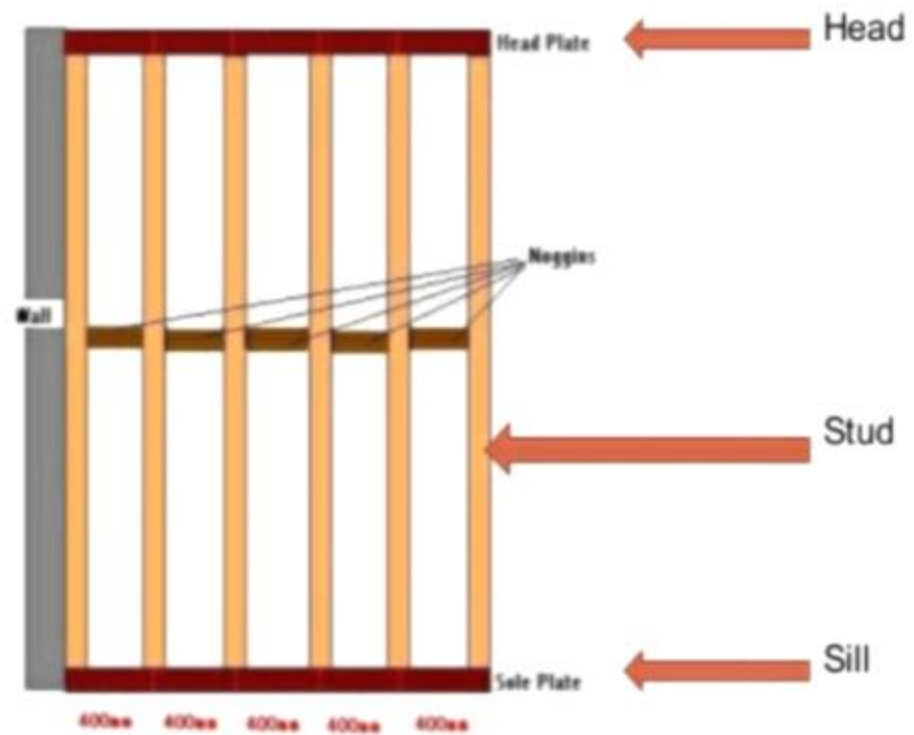
ADVANTAGES

1. Economical (Raw material is easily available)
2. Hard and durableCompressive strength is good enough for ordinary construction
3. Different orientations and sizes give different surface textures
4. Very low maintenance cost is required
5. Demolishing of brick structures is very easy, less time consuming and hence economicReusable and Recyclable
6. Highly fire rsistant
7. Produces less environmental pdlution during manufacturing process

Wooden partition

- Lighter in weight and easy to construct.
- Neither sound-proof nor fire-proof.
- Not suitable for damp locations.





Wooden partition wall

- **Wooden Partition Wall**

- Wooden partition walls are lighter in weight and simple to construct, neither sound-proof nor fire-proof.
- This partition wall is not appropriate for damp locations. Wooden partitions contain wooden edges that are connected to a sidewall and tied down to the floor.

Wood partition walls are two types –

- Common Partitions
- Trussed Partitions.
- Standard partitions are composed of vertical members referred to as studs bridged between the higher horizontal (head) and lower horizontal (sill) members.
- Trussed partitions are designed on the principle of the truss and are helpful wherever it is attainable to produce solely.
- Wood partitions are light-weight and easy to construct, but they are prone to rot, and insect infestation and are not fire-resistant either.

- 3.5 Brick masonry : Definition of different terms

COURSE

- A continuous horizontal layer of similar bricks or stones that are bonded with mortar in a masonry structure and is one unit high

BAT

- The portion of brick that is cut across the width.

a) Three Quarter Bat

When the length of the bat is equal to three-quarters of the length of the original brick.

b) Bevelled Bat

When a bat has its width bevelled.

c) Half Bat

When the length of a bat is equal to half of the length of the original brick.

BOND

- The method of arranging bricks in a pattern so that the individual units are tied together. Bonding is crucial to eliminate consecutive vertical joints both in the body as well as on the face of the wall, as this will create a weak brick structure. It is also referred as the adhesion between mortar and brick or stone units and when attaching several types of masonry walls by overlapping masonry units.

Stretching Bond

- Course of bricks that are all laid as stretchers. It is also called a running bond. If used as a structural bond it needs the proper reinforcement.

Heading Bond

- Course of bricks that are all laid as headers on the faces. A three-quarter bat is used in every other course as quoins and to properly overlap

Flemish Bond

- An alternate course of bricks that are composed of one header to one stretcher. It can also have several stretches in a row. Many times, the stretcher and headers will be of different color to create patterns.
- **English Bond**
- Alternate courses of stretchers and headers. Considered the strongest bond in brickwork. The second and the previous to last is a queen closer for all the heading courses. Alternate color shades are used for aesthetics.

Stack Bond

- Pattern when all courses are perfectly aligned. This type of bond is used for decorative purposes as it is a weak masonry structure with no strength

BULL NOSE

- A bull nose brick is a type of brick that has one or some of its corners rounded off. They are typically used to build soft and attractive curved edges to steps, ledges, or in capping walls. There are many types of bull nose bricks.

CLOSER

- The portion of the brick cut lengthwise in such a manner that its one long face remains uncut. Usually used to end a brick course or building beautiful corners.

Queen Closer (Half)

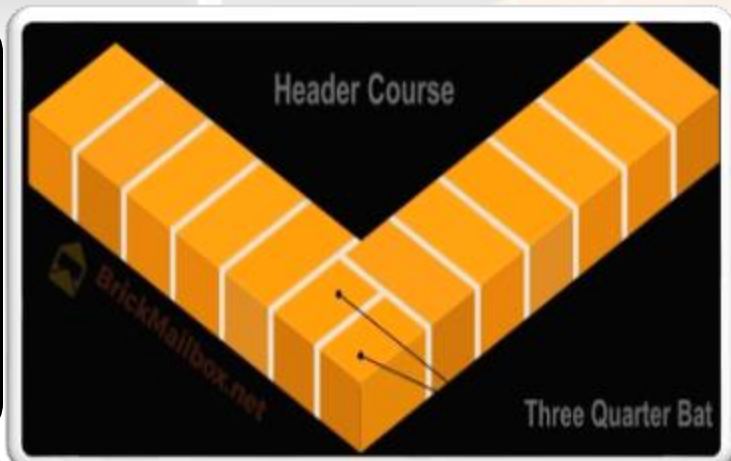
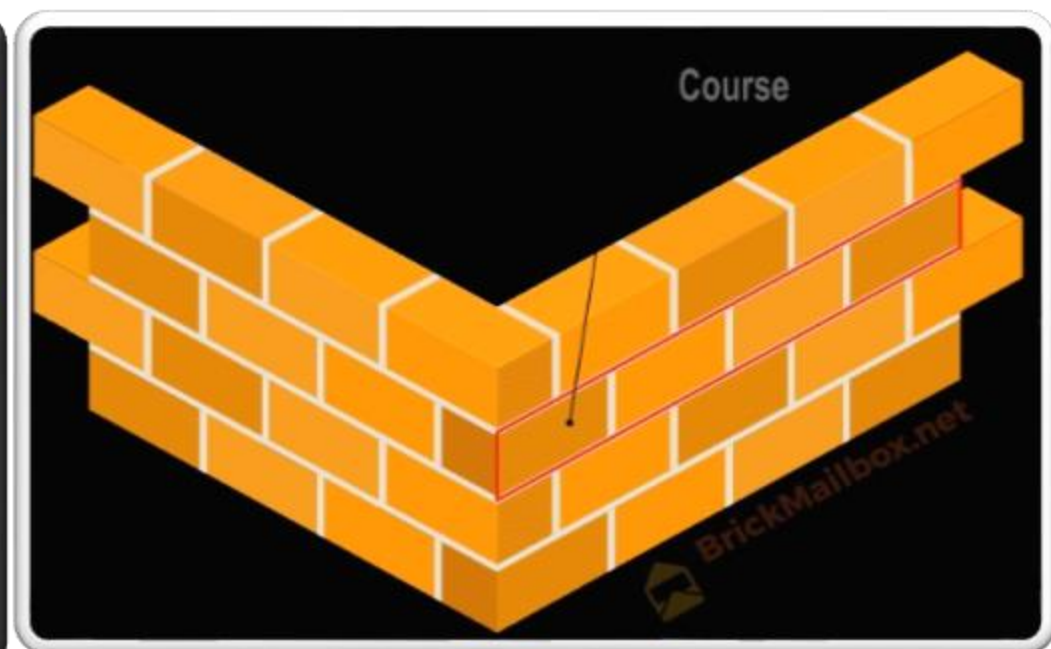
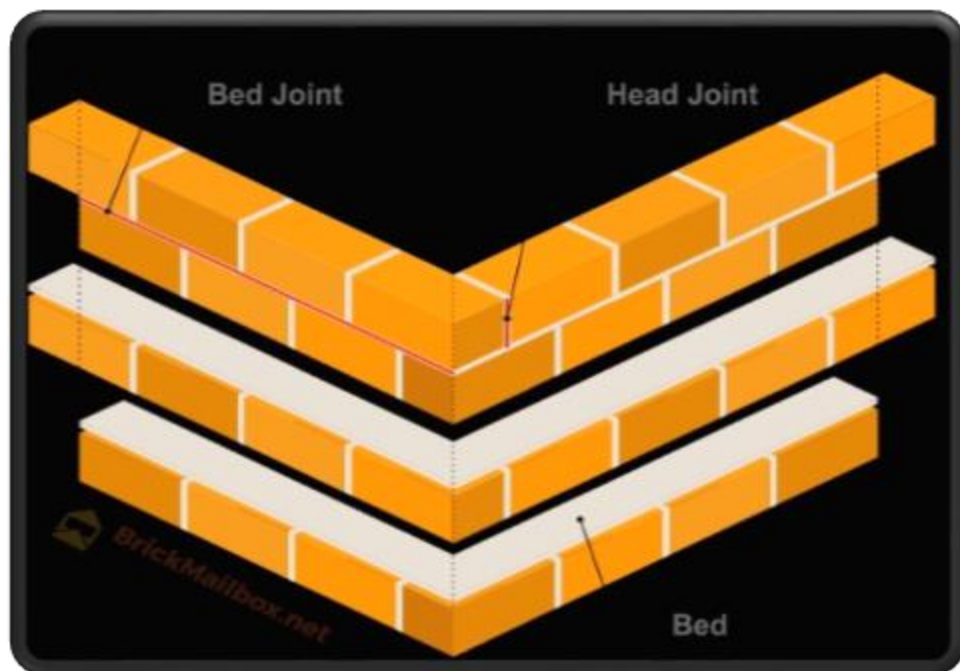
- The piece of brick taken by cutting a brick lengthwise into two parts.

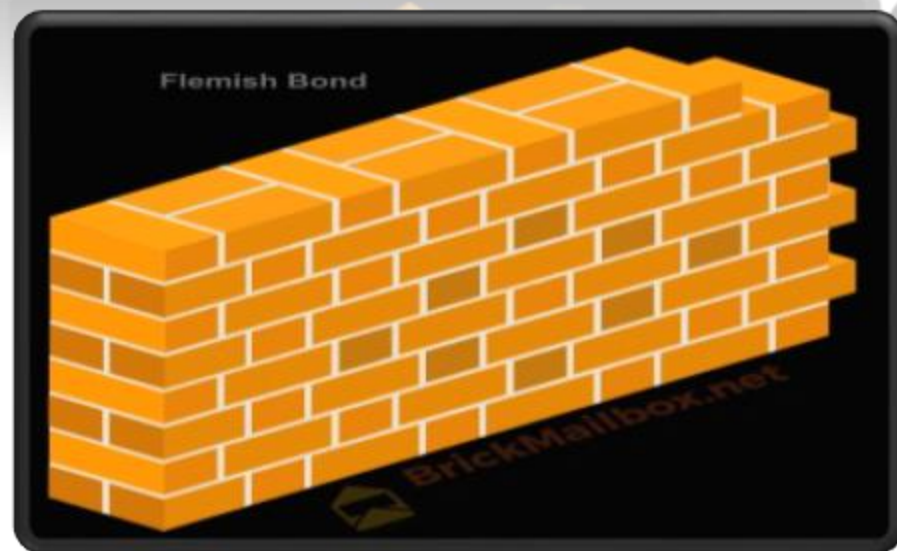
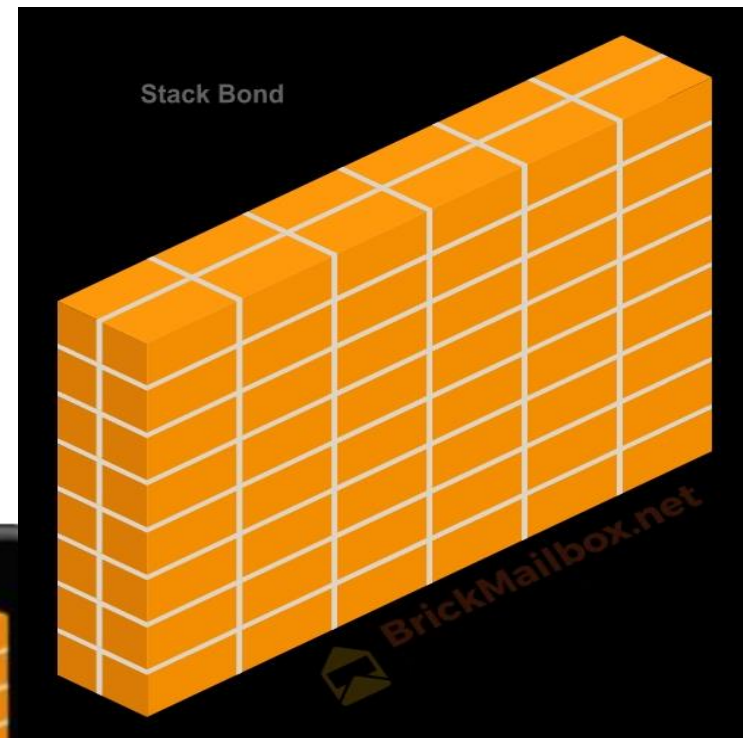
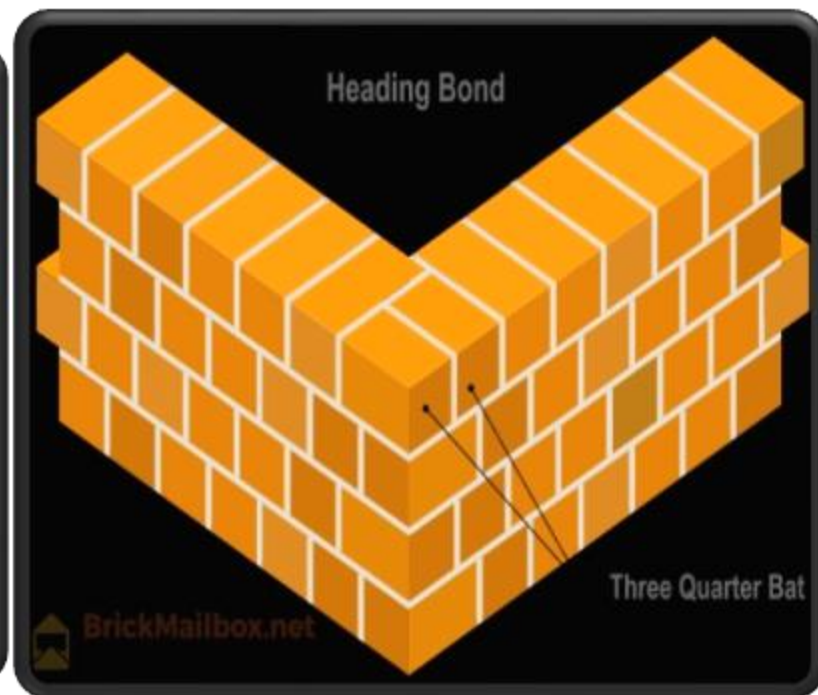
Queen Closer (Quarter)

- When the queen closer is cut in half, then it is called a queen closer quarter.

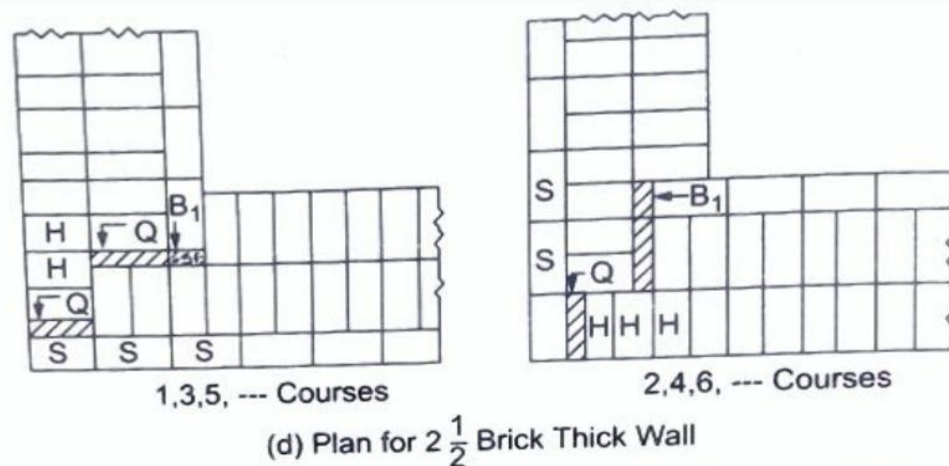
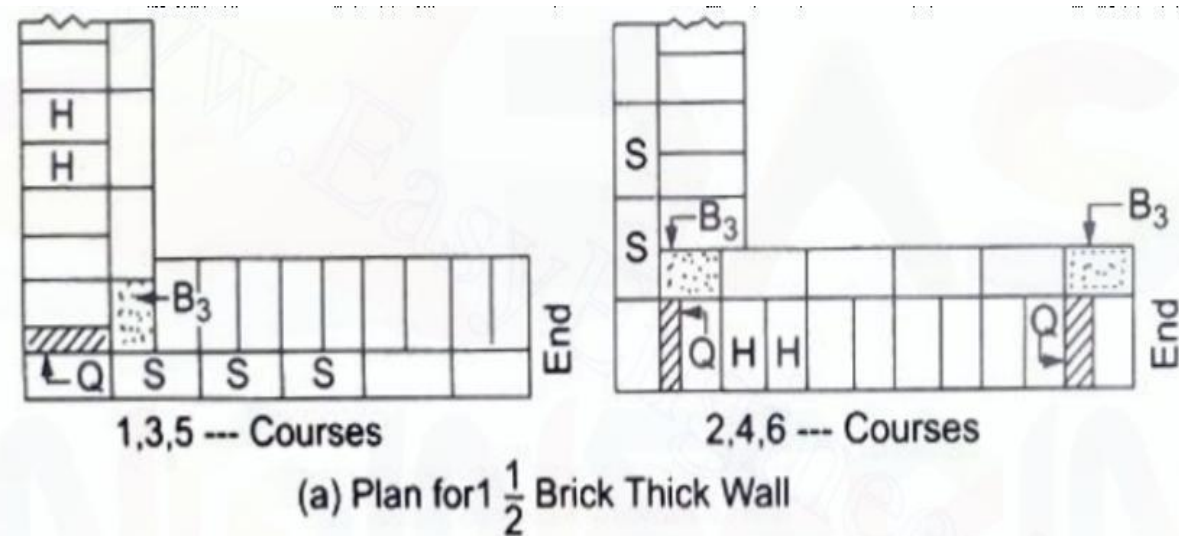
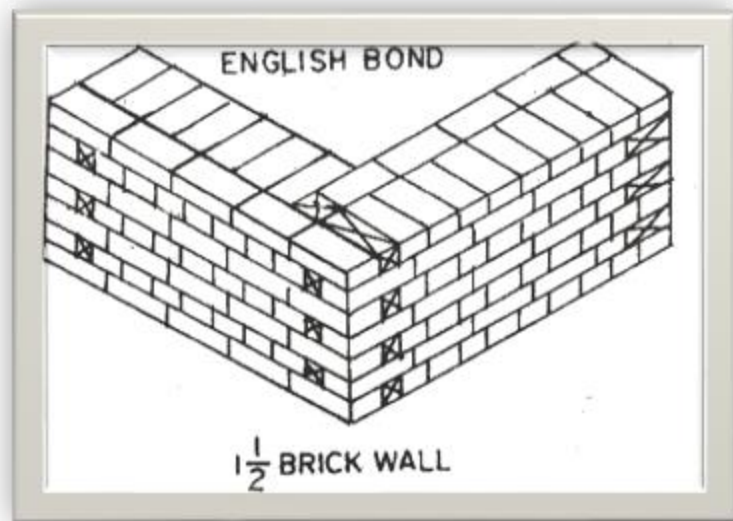
King Closer

- Brick that is obtained by cutting from the center of one header to the center of the stretcher on the other side. They are used to finish corners.





- . The following additional points should be noted in English bond construction:
 - (1) In English bond, a heading course should never start with a queen closer as it is liable to get displaced in this position.
 - (2) In the stretcher course, the stretchers should have a minimum lap of $\frac{1}{4}$ th their length over the headers.
 - (3) Walls having their thickness equal to an even number of half bricks, i.e., one brick thick wall, 2 brick thick wall, 3 brick thick wall and so on, present the same appearance on both the faces, i.e. a course consisting of headers on front face will show headers on the back face also.
 - (4) In walls having their thickness equal to an odd number of half brick, i.e. $1\frac{1}{2}$ brick thick walls or $2\frac{1}{2}$ brick thick walls and so on, the same course will show stretchers on one face and headers on the other.
 - (5) In thick walls the middle portion is entirely filled with header to prevent the formation of vertical joints in the body of the wall.
 - (6) Since the number of vertical joints in the header course is twice the number of joints in the stretcher course, the joints in the header course are made thinner than those in the stretcher course.



S = Stretcher Facing; H = Header Facing; Q = Queens Closer;
B1 = Quarter Bat (Quarter Queen's Closer)

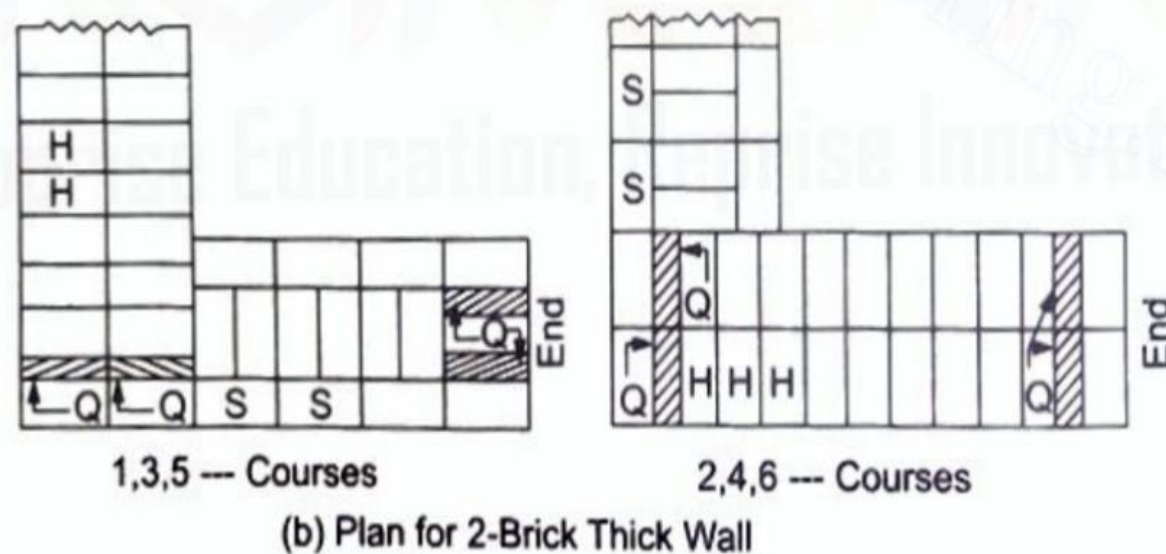
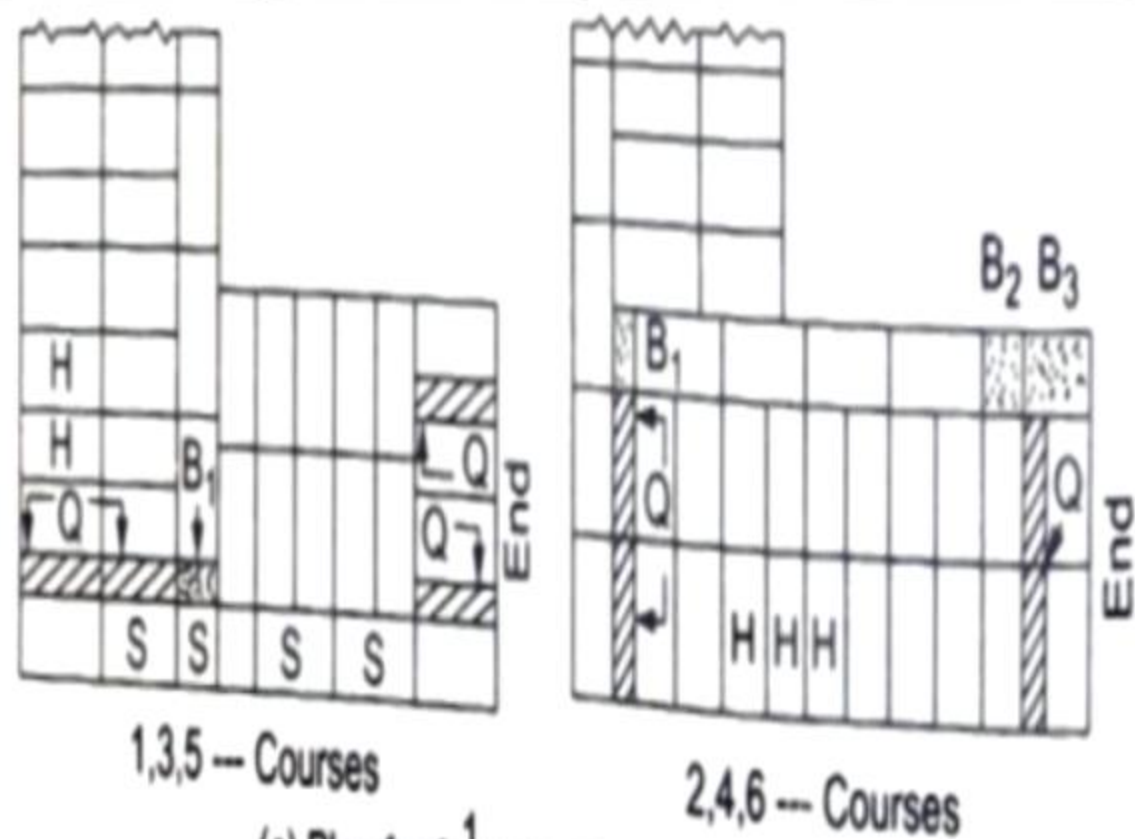
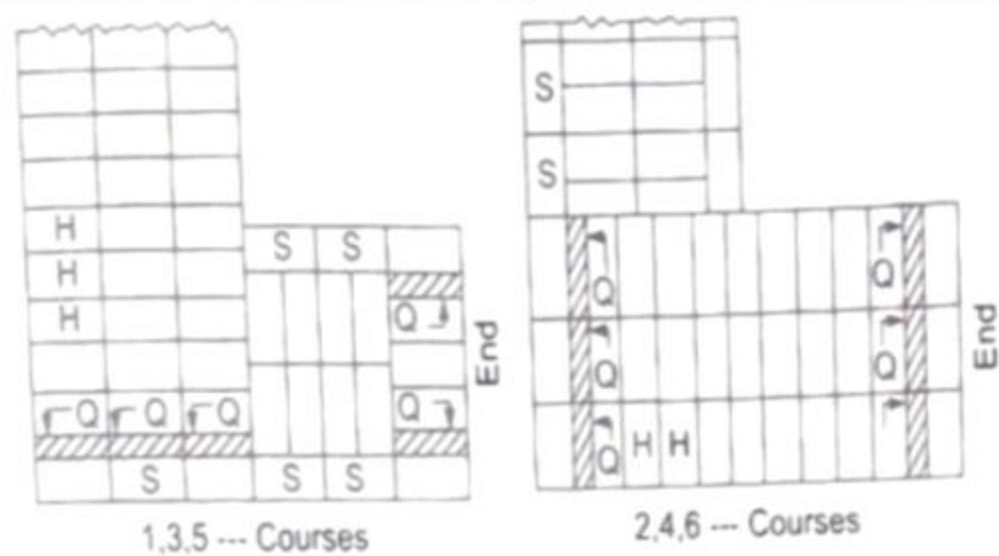


Fig. 3.17 English bond



(c) Plan for $2\frac{1}{2}$ Brick Thick Wall



(d) Plan for 3-Brick Thick Wall

S = Stretcher Facing, H = Header Facing, Q = Queens Closer,

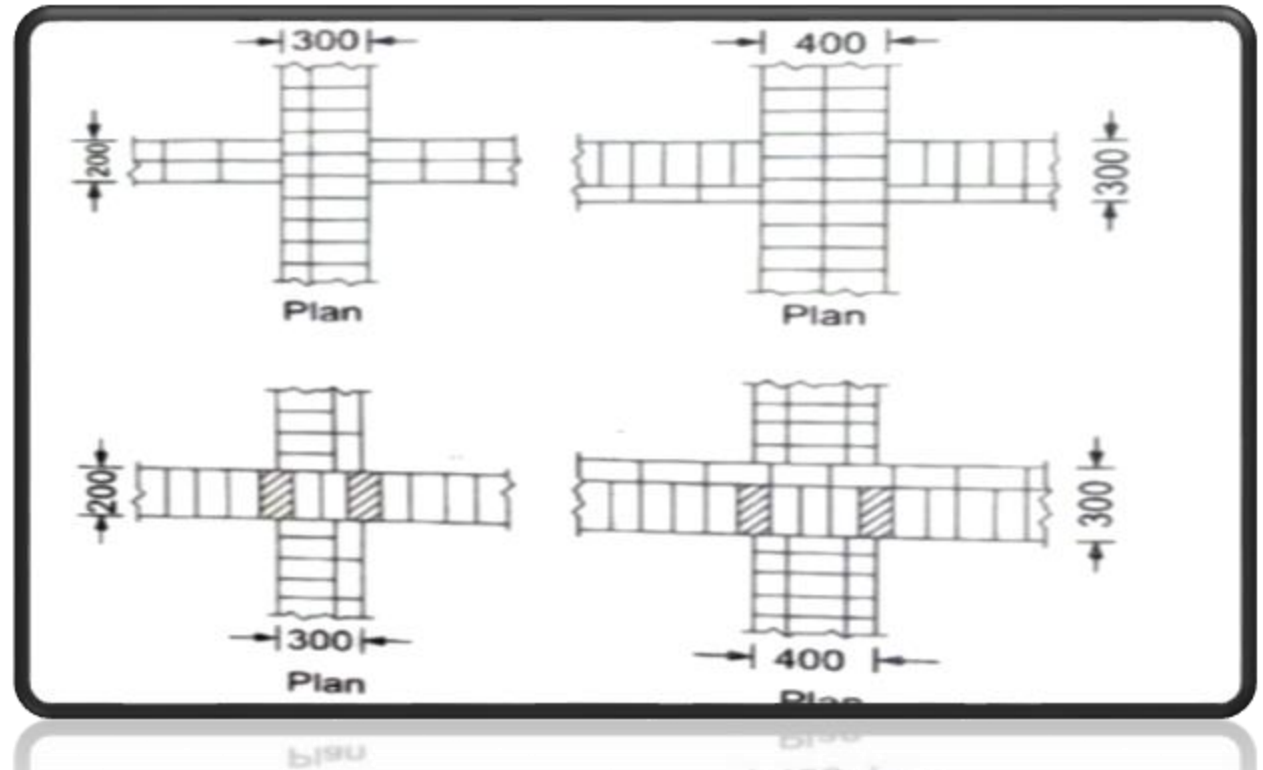
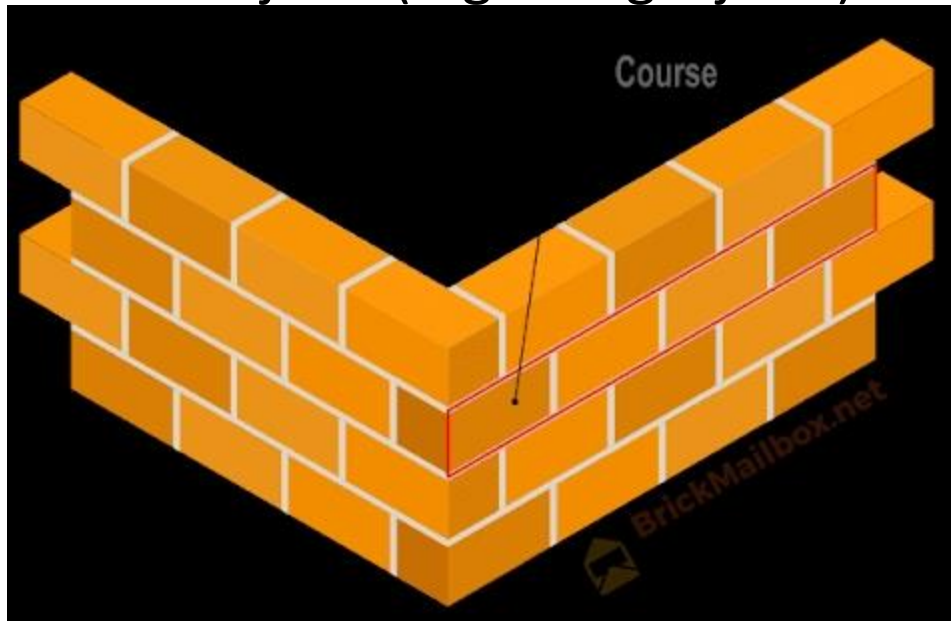
$$B_1 = \frac{1}{4} \text{ Bat}, B_2 = \frac{1}{2} \text{ Bat}, B_3 = \frac{3}{4} \text{ Bat}$$

Bond at Junction:-

When two wall meet and intersect the Meeting point is known as junction.

It of two types

1. CROSS JOINT (X joint) it is arranged using English bond.
2. T JOINT , it is arranged by using English or double Flemish Bond.
3. L joint (right angle joint)



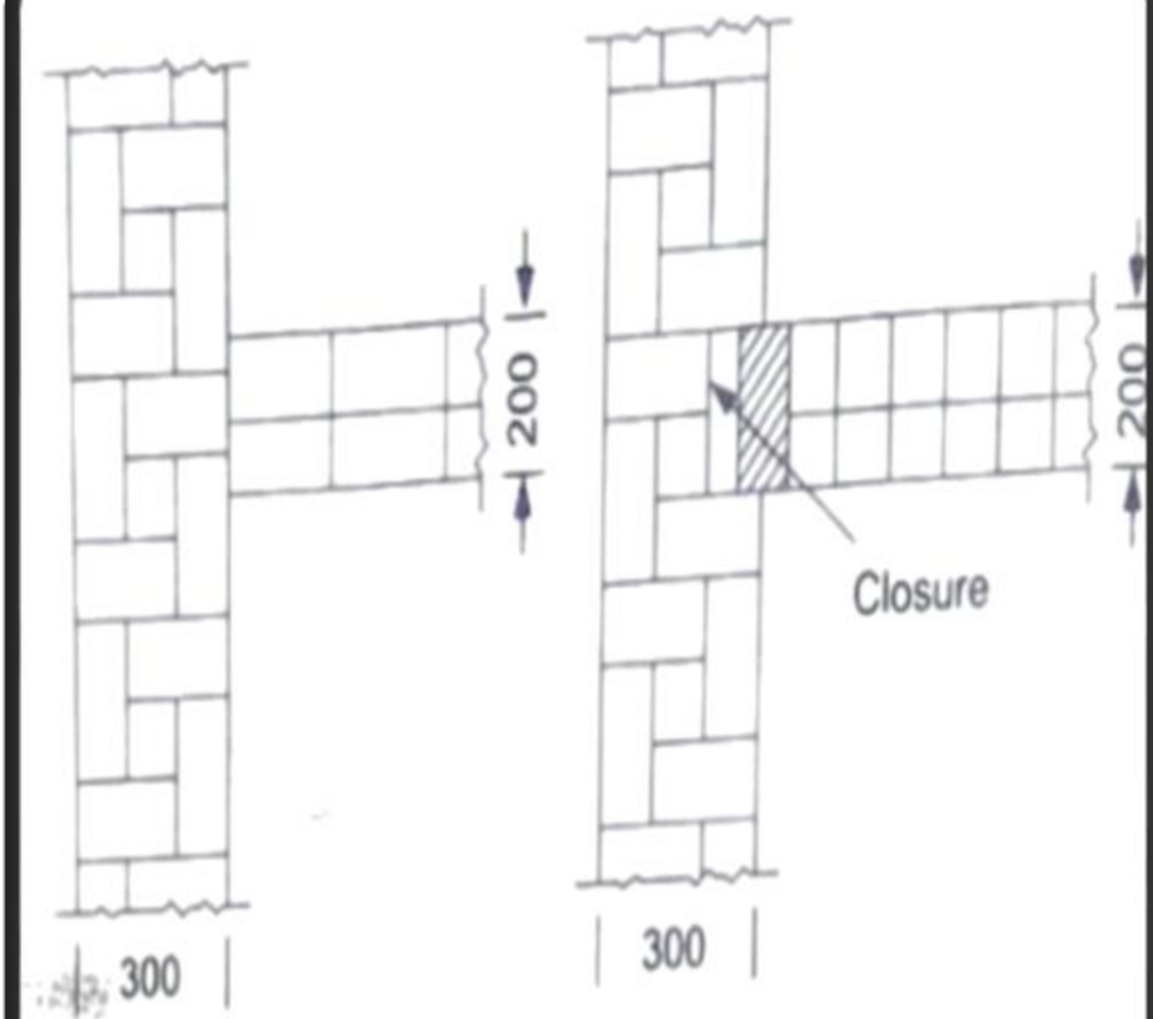


Fig. 3.35 Tee-Junction in Flemish Bond

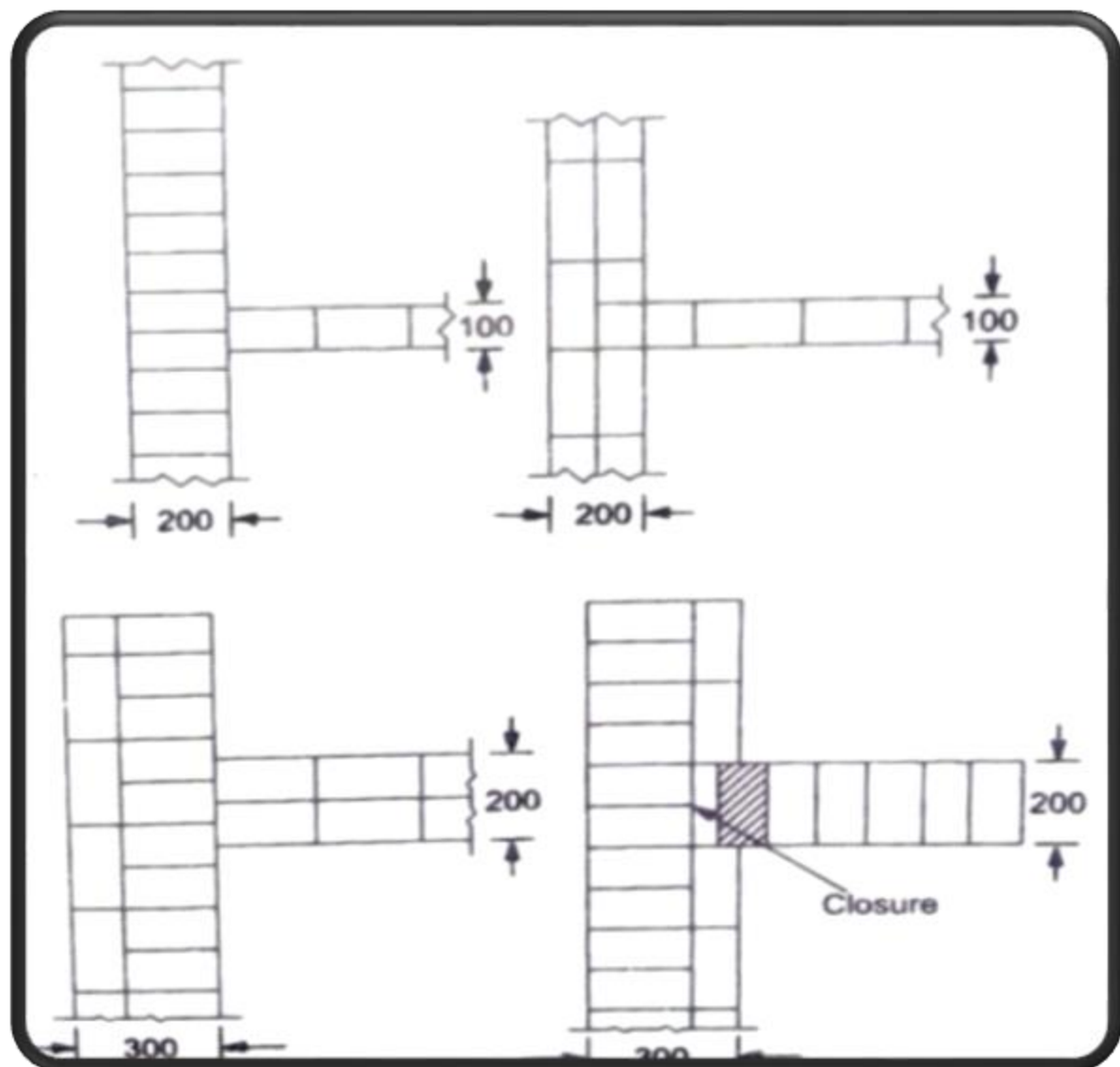
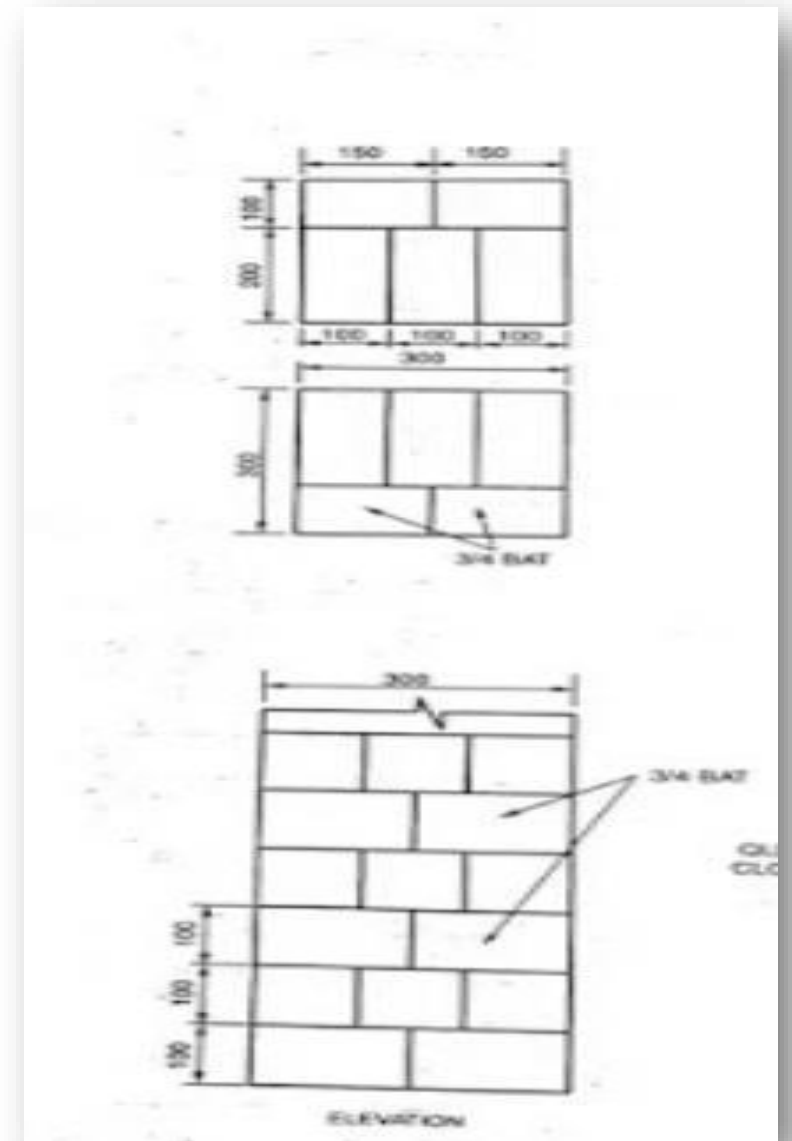
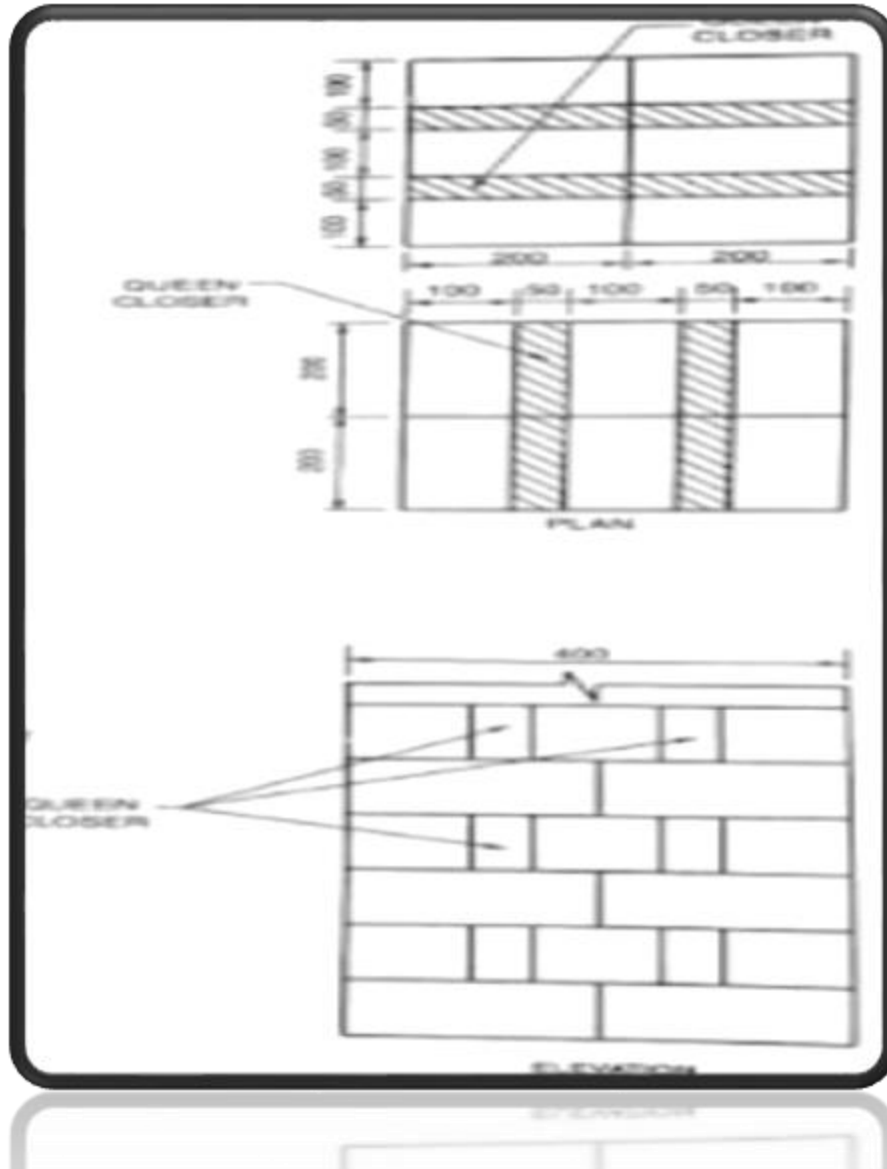


Fig. 3.32 Tee-Junction in Flemish Bond

- Thickness for 1 and 1-1/2 brick square pillars in English bond



Stone Masonry

- The construction of stones bonded together with mortar is termed as stone masonry where the stones are available in a abundance in nature, on cutting and dressing to the proper shape, they provide an economical material for the construction of various building components such as walls, columns, footings, arches, lintels, beams etc.

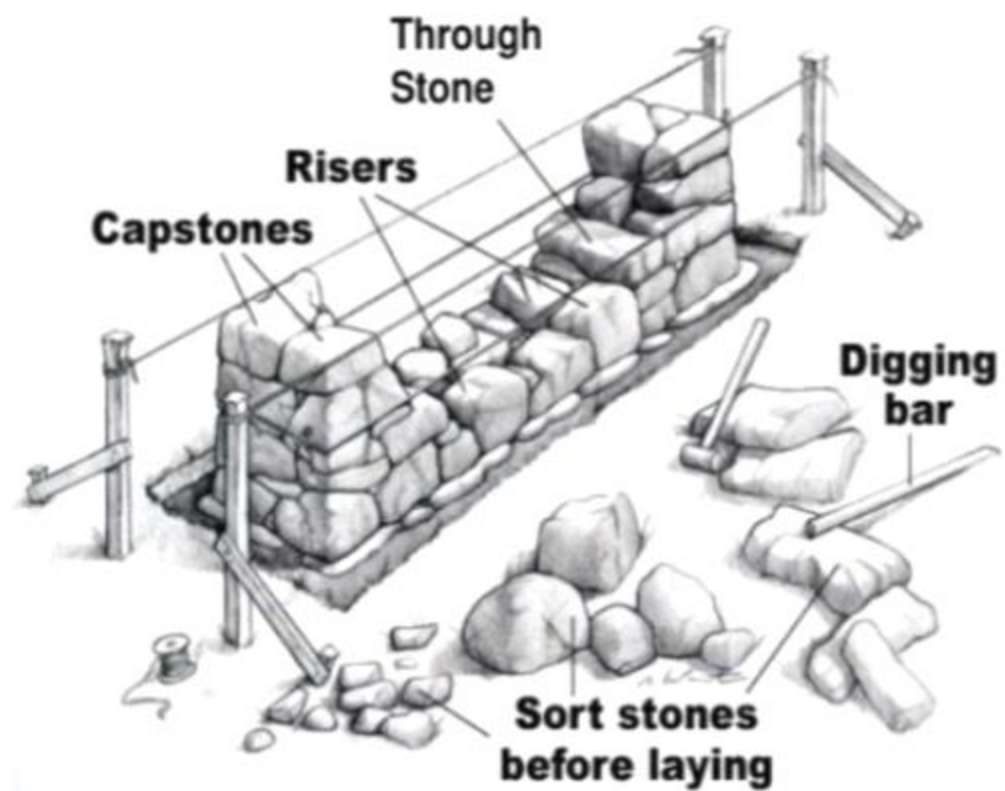


Uses

- 1) Building foundations, walls, piers, pillars, and architectural works.
- 2) Lintels, Beams, beams Arches, domes etc.,
- 3) Roofs and Roof coverings.
- 4) Cladding Works
- 5) Dams, light houses, monumental structures.
- 6) Paving jobs
- 7) Railway, ballast, black boards and electrical switch

Selection of Stone masonry

- 1) Availability
- 2) Ease of working
- 3) Appearance
- 4) Strength and stability
- 5) Polishing characteristics
- 6) Economy
- 7) Durability



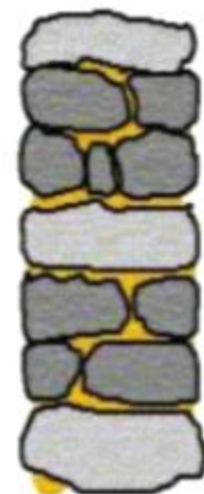
Traditionally
built wall



Wall
delamination



Wall
crumbling



SOLUTION:
Through Stones

Types of Stone Masonry:

Based on the arrangement of the stone in the construction and degree of refinement in the surface finish, the stone masonry can be classified broadly in the following two categories

1. Rubble masonry
2. Ashlar masonry

1) Rubble masonry:

In this category, the stones used are either undressed or roughly dressed having wider joints. This can be further subdivided as uncoursed, coursed, random, dry, polygonal and bint.

- ***(i) Uncoursed rubble masonry:*** This is the cheapest, roughest and poorest form of stone masonry. The stones used in this type of masonry very much vary in their shape and size and are directly obtained from quarry. Uncoursed rubble masonry can be divided into the following.

- a) Uncoursed random rubble
- b) Uncoursed squared rubble

Uncoursed rubble masonry

- ***a) Uncoursed random rubble masonry:*** The weak corners and edges are removed with mason's hammer. Generally, bigger stone blocks are employed at quoins and jambs to increase the strength of masonry.

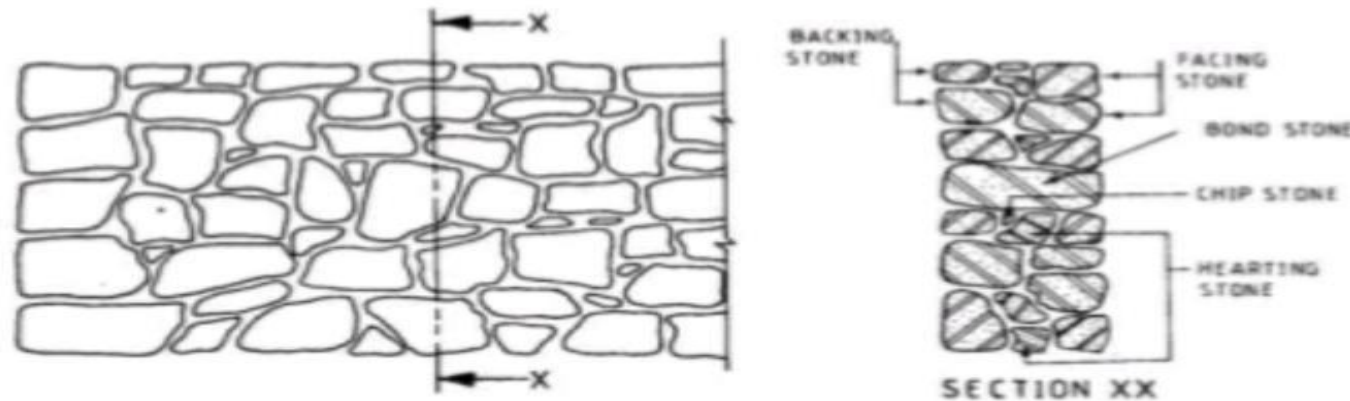


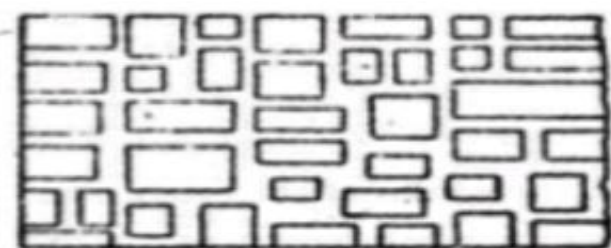
FIGURE 1- RANDOM RUBBLE MASONRY



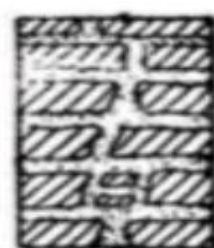
Uncoursed rubble masonry

- *b) Uncoursed squared rubble:*

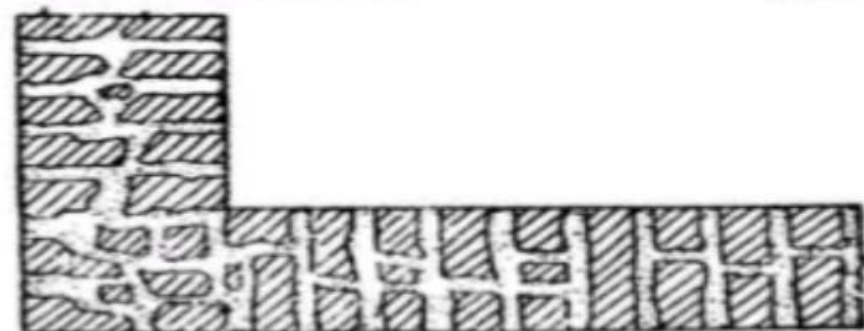
In this type the stone blocks are made roughly square with hammer. Generally the facing stones are given hammer-dressed finish. Large stones are used as quoins. As far as possible the use of chips in bedding is avoided.



Elevation



Section



Plan

Ashlar Masonry

- This type of masonry is built from accurately dressed stones with uniform and fine joints of about 3mm thickness by arranging the stone blocks in various patterns.
- The backing of Ashlar masonry walls may be built of Ashlar masonry or rubble masonry. The size of stones blocks should be in proportion to wall thickness.

Ashlar Masonry



Ashlar fine

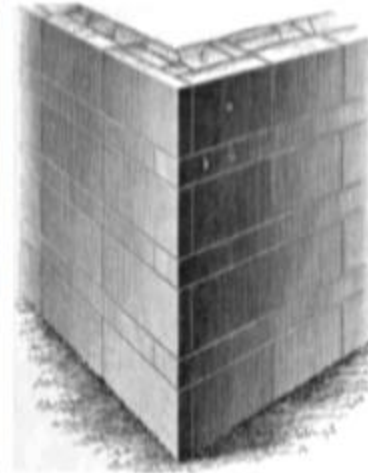


Ashlar rough

Ashlar Masonry

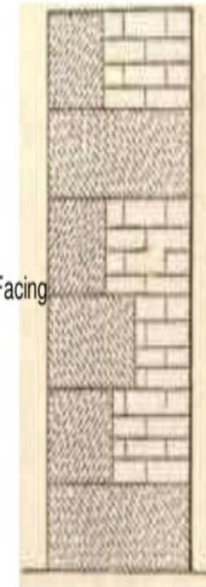


Ashlar rock or quarry faced



Ashlar block in course

Ashlar Masonry



Ashlar facing



Ashlar chamfered

String course.

- It is a horizontal projecting course of masonry, usually projecting from the face of the wall, intended to throw off rain water. It also gives architectural appearance and adds to the strength of the wall.

Cornice.

- It is the projecting ornamental course, usually moulded to add to the appearance of the wall. A cornice is placed in a wall, at the junction of wall and roof.

Coping.

- The top of a parapet wall is finished with a special course to protect it from rain water. This course is called coping

Parapet.

- It is a low wall built round a terrace in the case of buildings with flat roofs. It is intended primarily to act as a fence wall

Corbel:-

- A corbel is a projecting stone which is usually provided to serve as a support for roof truss, beam, weather shed etc.
- The corbel are generally moulded and given ornamental treatment.
- The Corbel should **extend at least $\frac{2}{3}$ of their length** into the wall

Throating :

- A groove is provided on the underside of sill, cornice & coping so that the rain water can be discharged clear of the wall surface. It is known as **throating**.

Through stone:

- In stonework, some stones at regular intervals are placed right across the wall Such stones are known as the through stones or throughs or bond stones.
- The through stones should be non-porous so as to prevent the entry of moisture through the wall.
- They should also be strong and of sufficient thickness so as to avoid the danger of fracture due to any slight settlement of the wall.

BLOCKING COURSE

- It is a top most course of stone masonry provided immediately above the cornice to prevent the tendency of the cornice to overturn. It also adds to the aesthetics of the cornice.

Buttress:

A buttress is a sloping or a stepped pier and it is provided to work as lateral support of the wall.

Pilaster:

A right-angled columnar projection from a wall or a pier is known as a pilaster.

TEMPLATE:

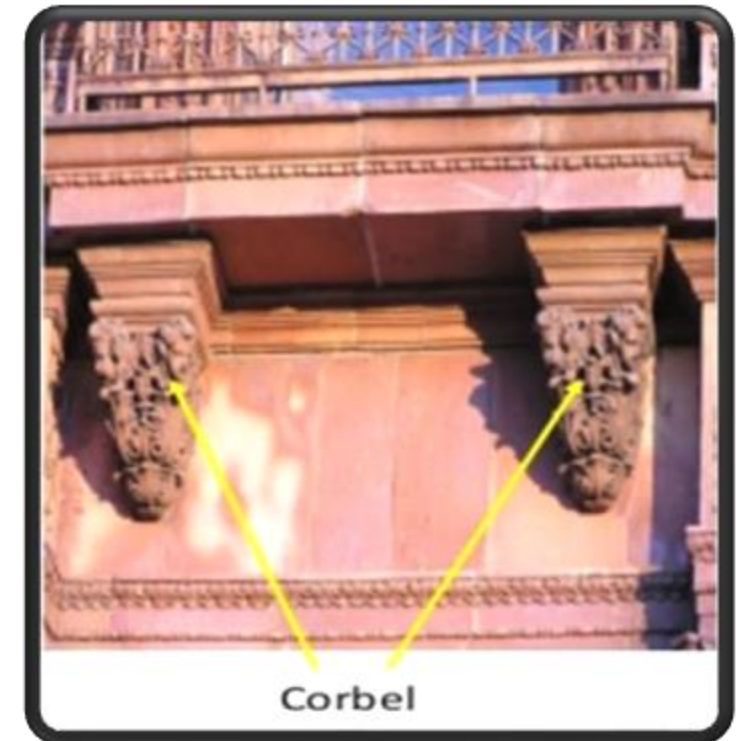
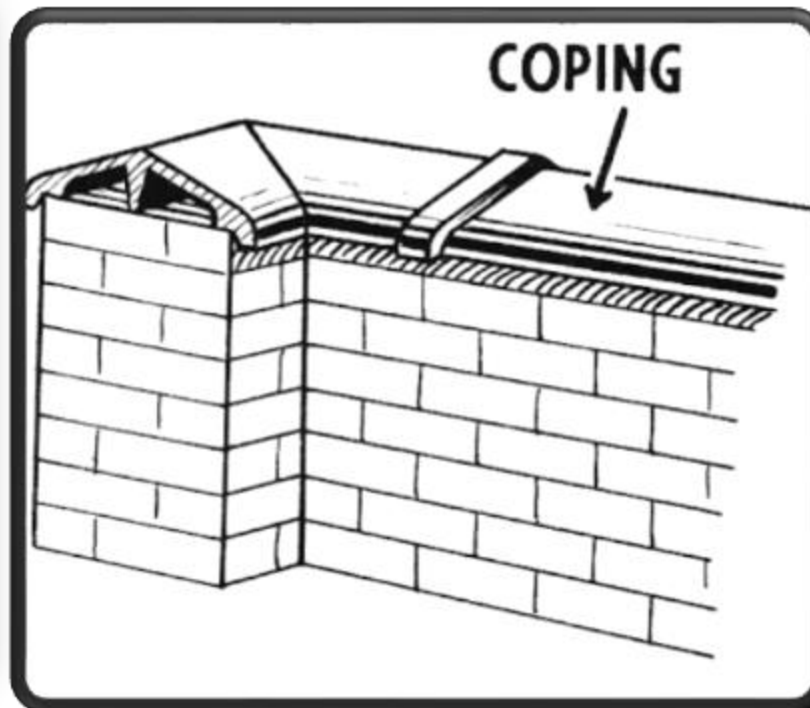
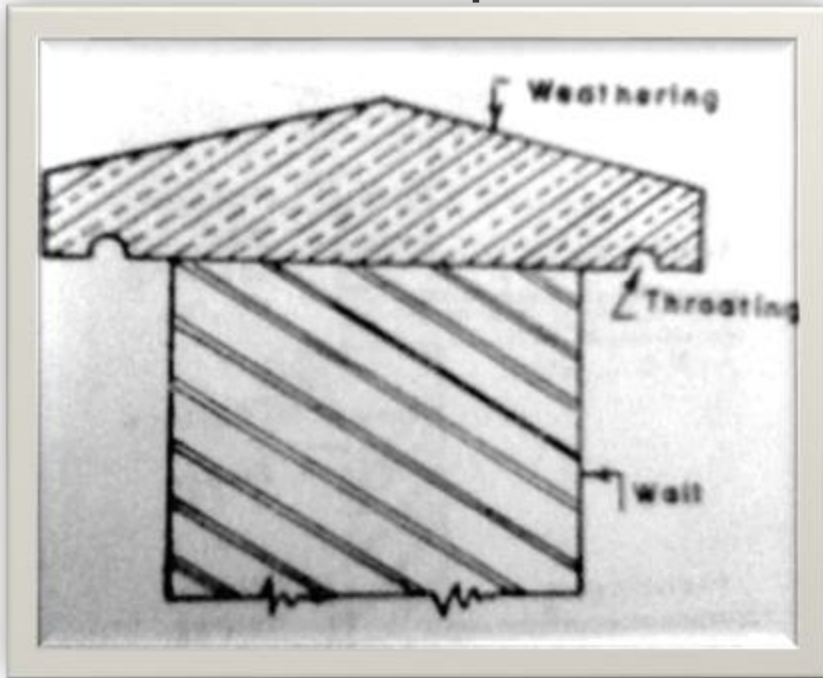
Pieces of stones placed under the end of a beam to distribute the load over a greater area.

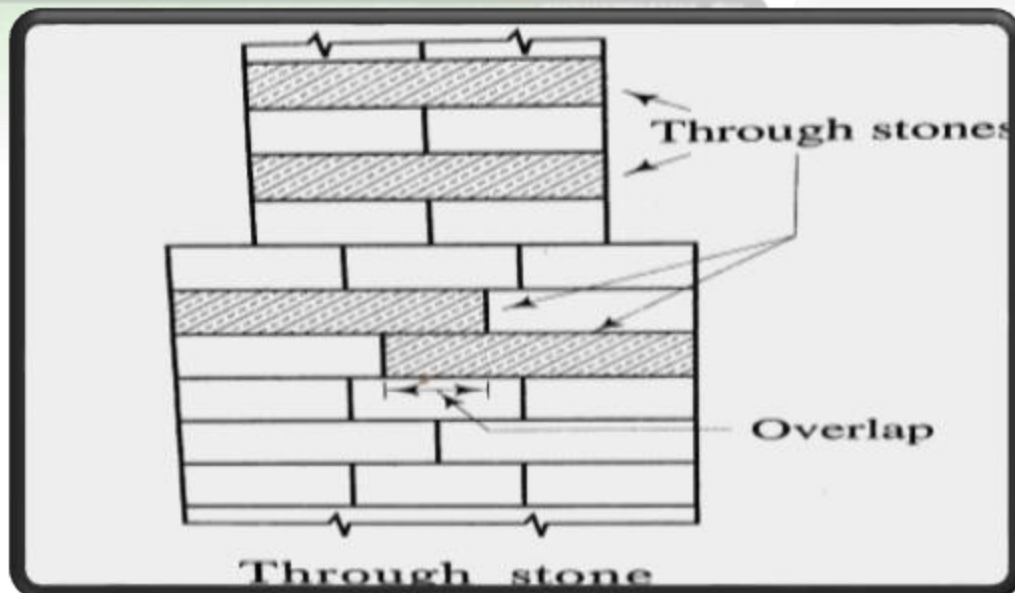
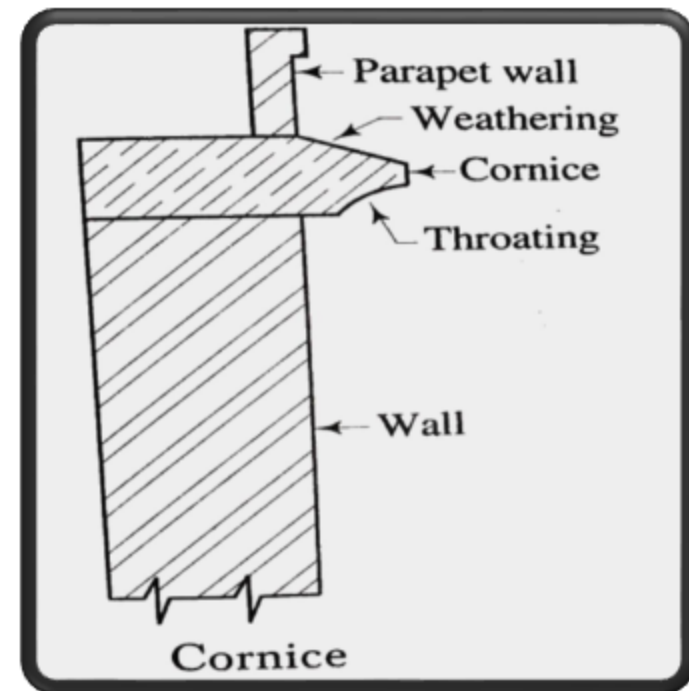
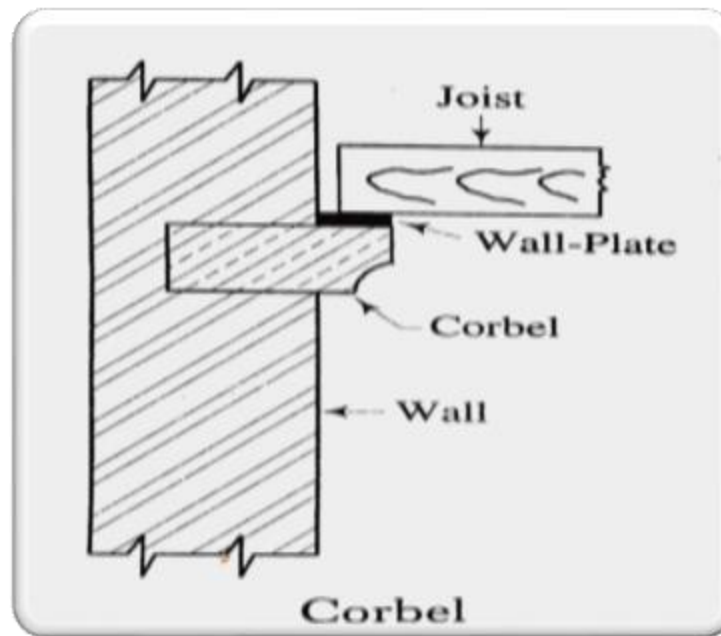
Grouting:-

The process of filling voids in masonry of stone is known as grouting.

Parapet:

It is the portion of low height wall constructed along the edge of the roof to protect the users.







Without Arch

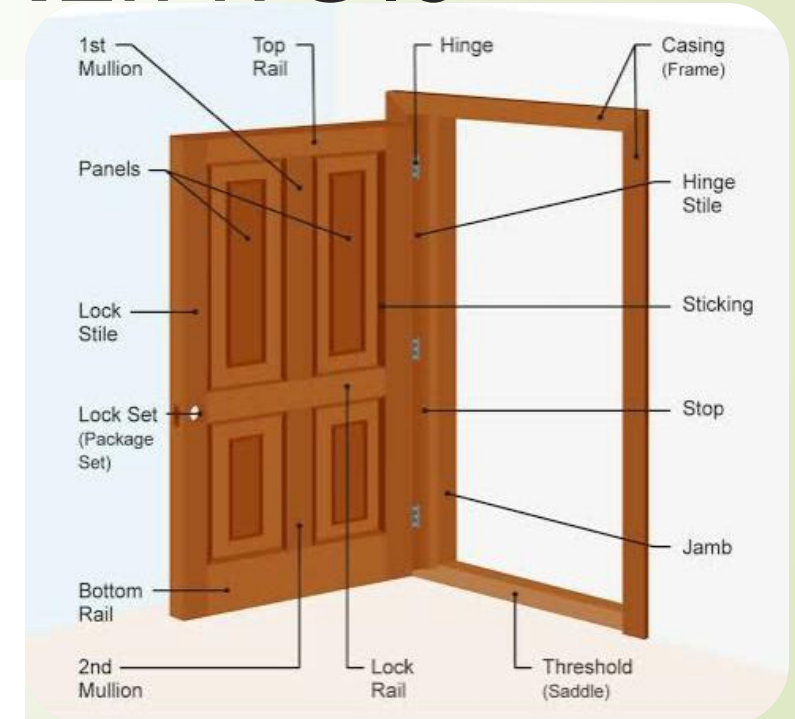
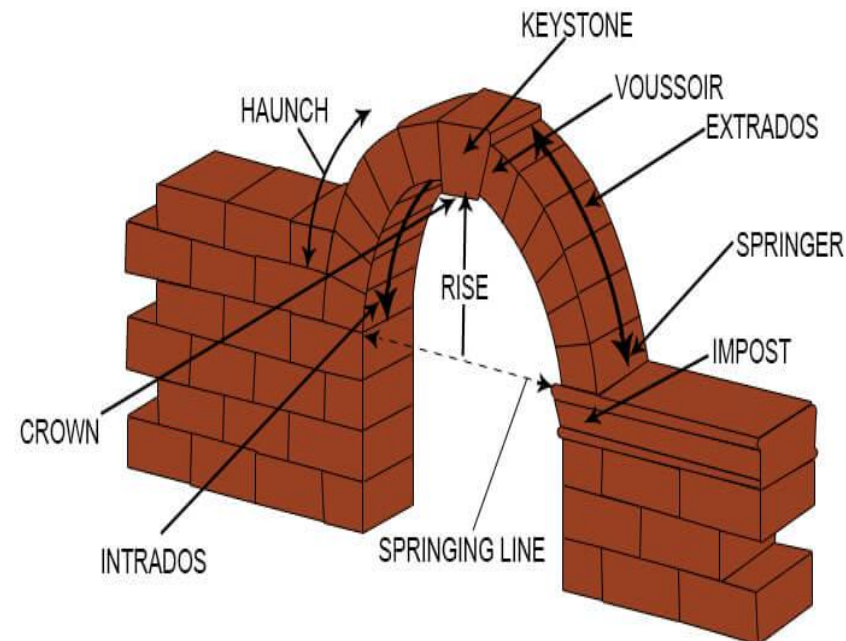
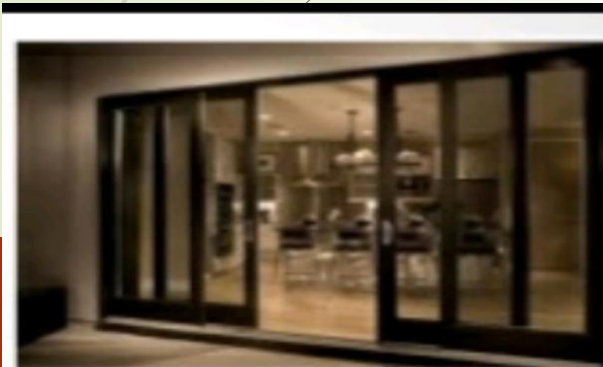


With Arch

CHAPTER 4



Doors, Windows & Lintels





➡ DOORS, WINDOWS AND LINTELS

4.1 GLOSSARY OF TERMS USED IN DOORS AND WINDOWS

4.2 DOORS – DIFFERENT TYPES OF DOORS

4.3 WINDOWS – DIFFERENT TYPES OF WINDOWS

4.4 PURPOSE OF USE OF ARCHES AND LINTELS

Technical Terms

1. **Frame** - It is a combination of several wooden members to support the door
2. **Style** - Style is an external vertical member of the shutter.
3. **Top rail** - It is the topmost horizontal member of the shutter
4. **Lock rail** - It is the central horizontal member of the shutter where locking attachments are fixed.
5. **Bottom rail** - It is the lowest horizontal member of the shutter.
6. **Shutter** - The complete assembly of the styles panels and rails is known as a shutter.
7. **Panel** - It is the enclosed area between the rails.

8. **Sash** - It is a frame made of light sections and is used iron fixing the glass in the panels.

9. **Mullion** - It is a vertical member running through a shutter or frame.

10. **Louver** - Louver is a timber piece which is attached in inclined position within a frame.

11. **Horn** - It is a horizontal projection of head or sill beyond the face of the door or window frame. Generally horn is 15 cm long.

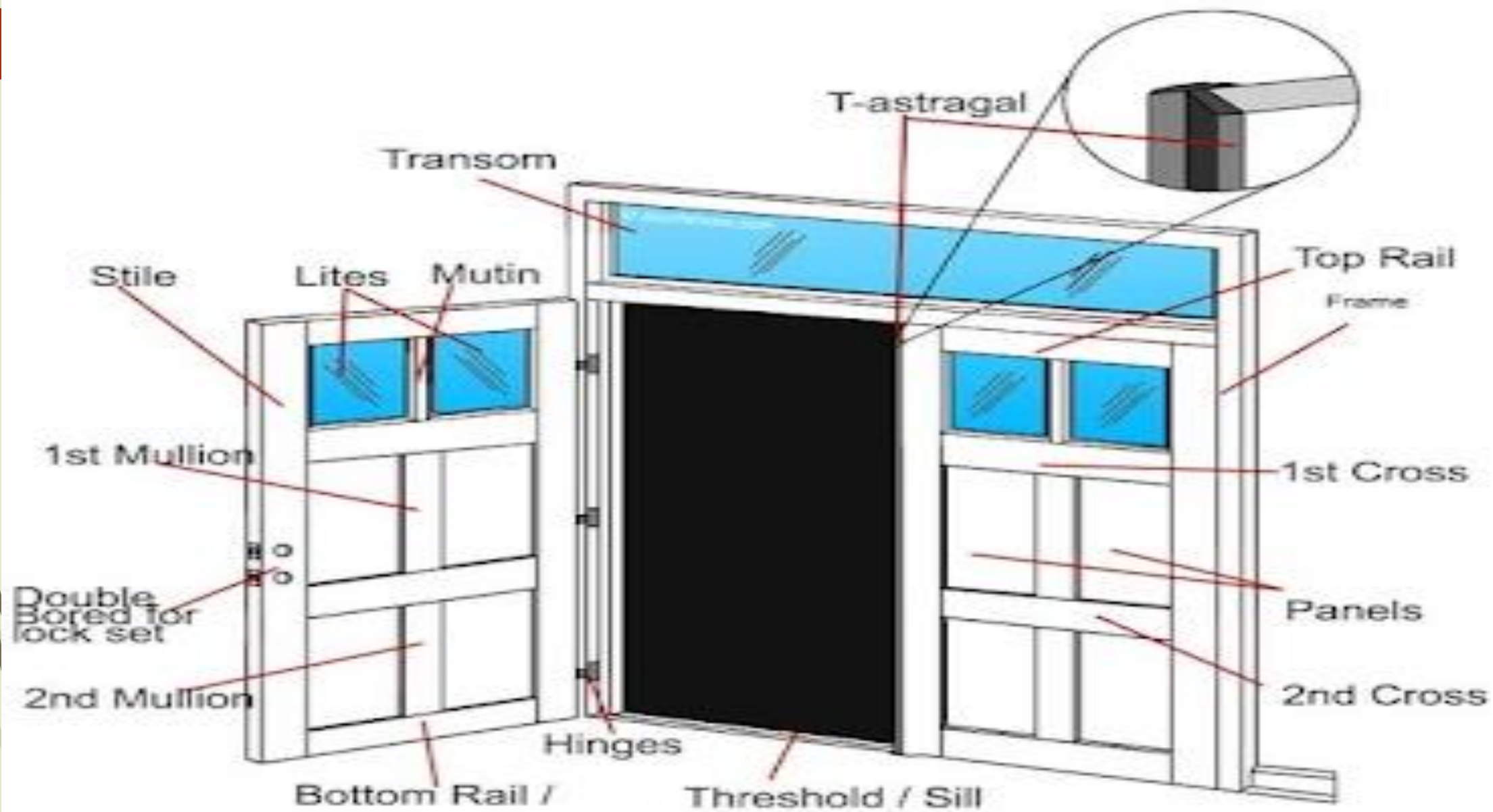
12. **Hold-fasts** - These are provided on vertical sides of the vertical door frames to keep the frame in required position. They are made of mild steel flat bars about 3 cm wide, 6 cm thick and 20 to 25 cm long.

13. **Sill** - It is the bottom most horizontal member forming the frame.

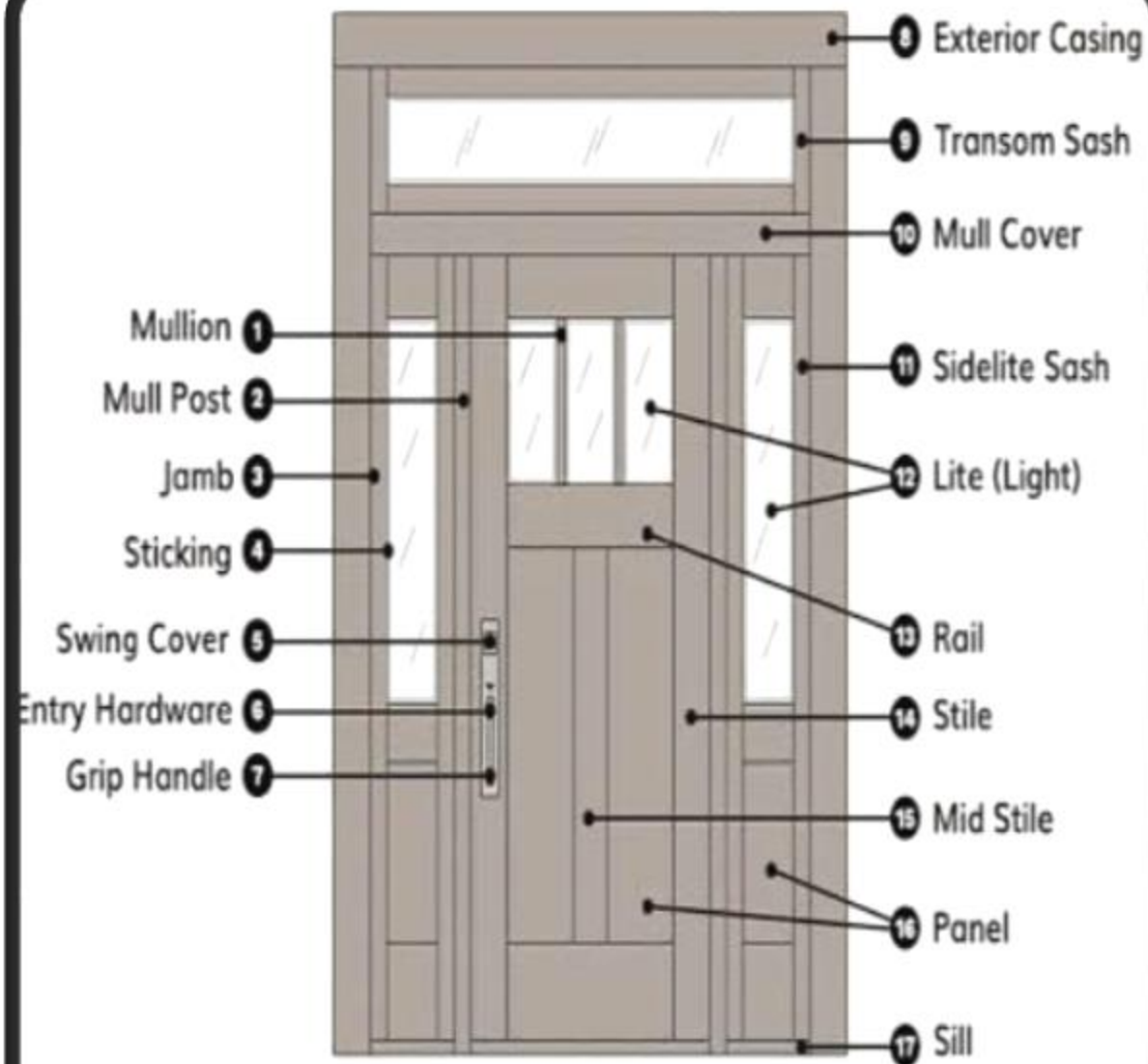
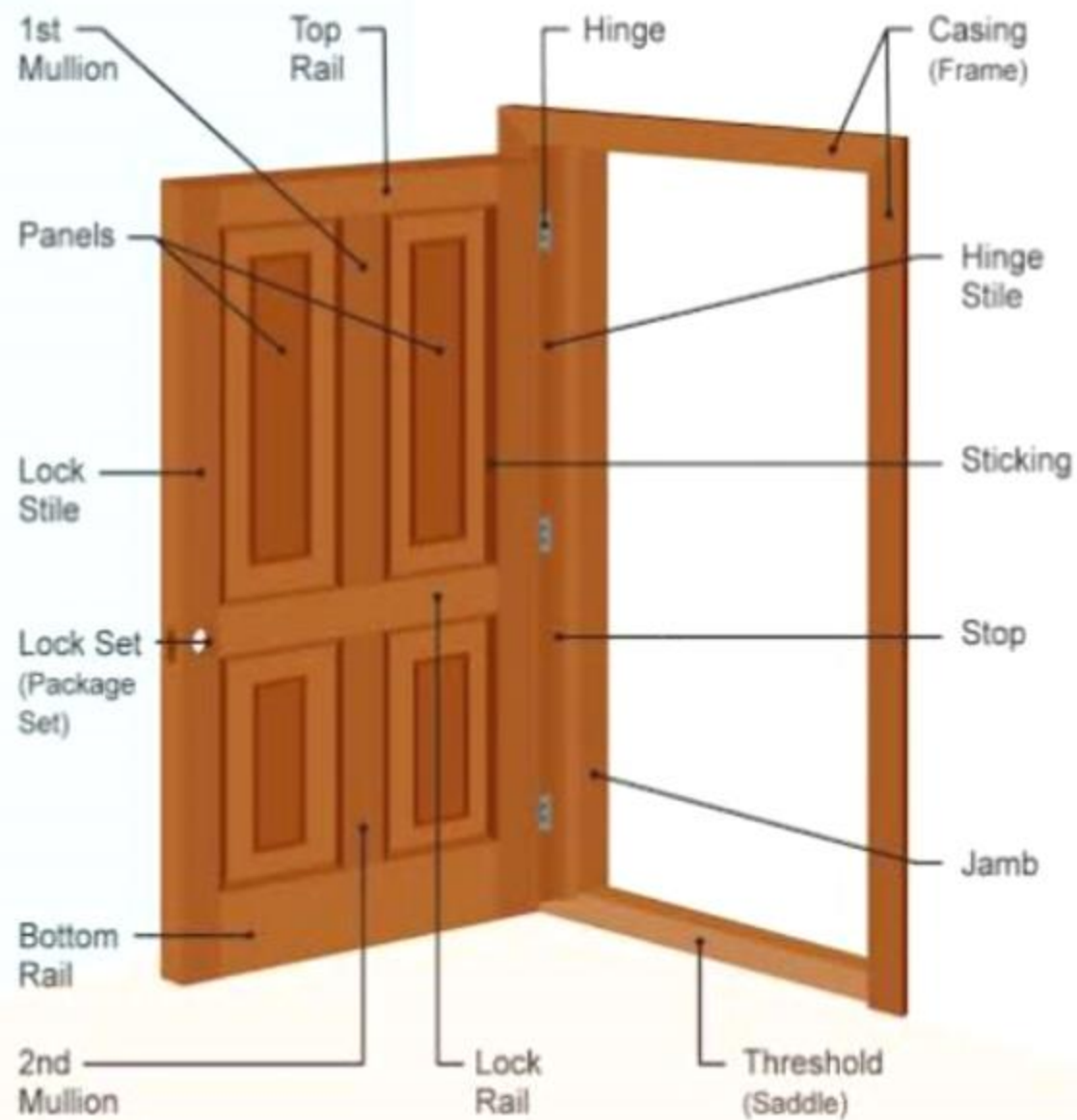
14. **Jamb** - It is the vertical face of a door or windows opening which supports the frame.

15. **Transom** - It is a horizontal member which divides the door or window frame into several panels.

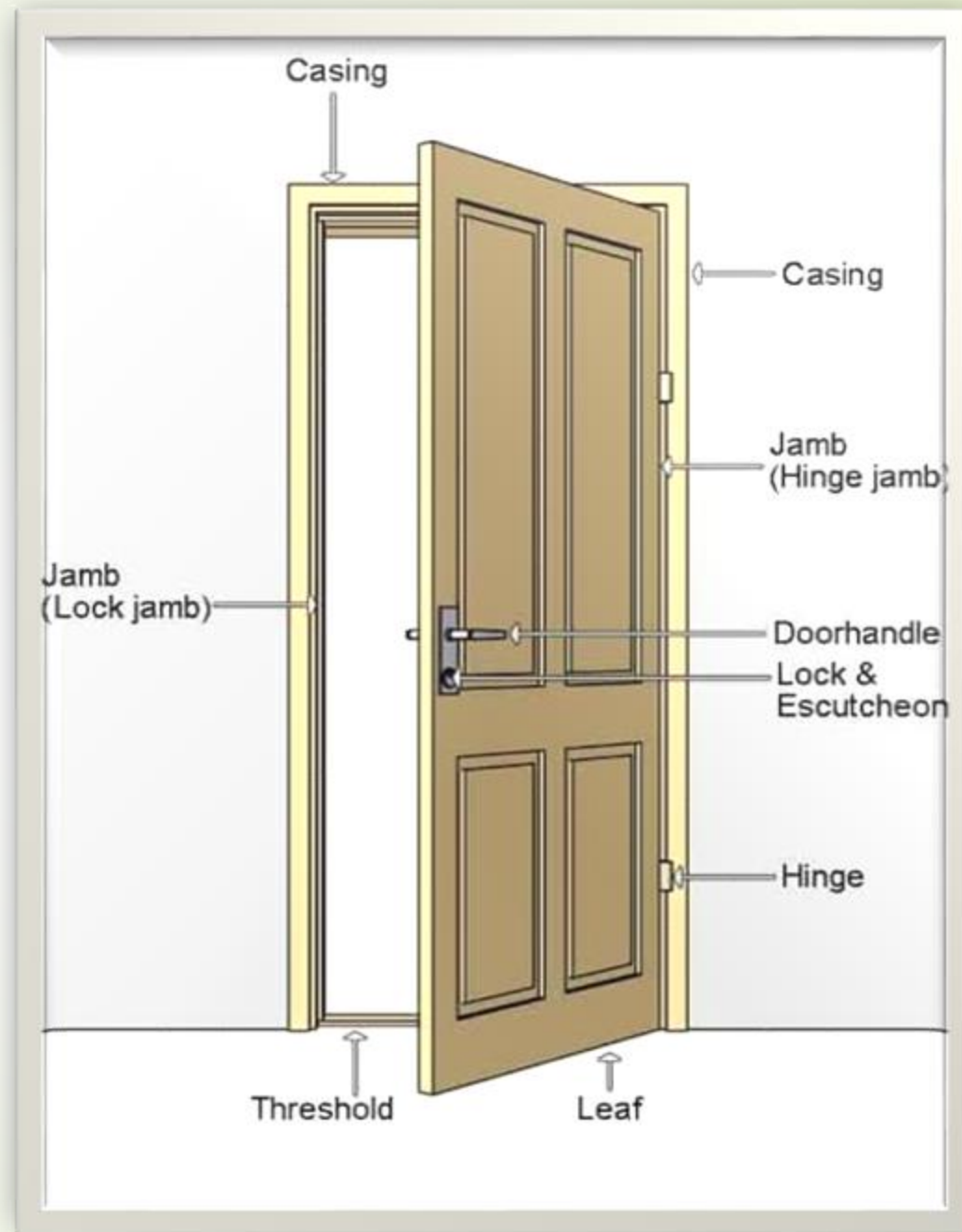
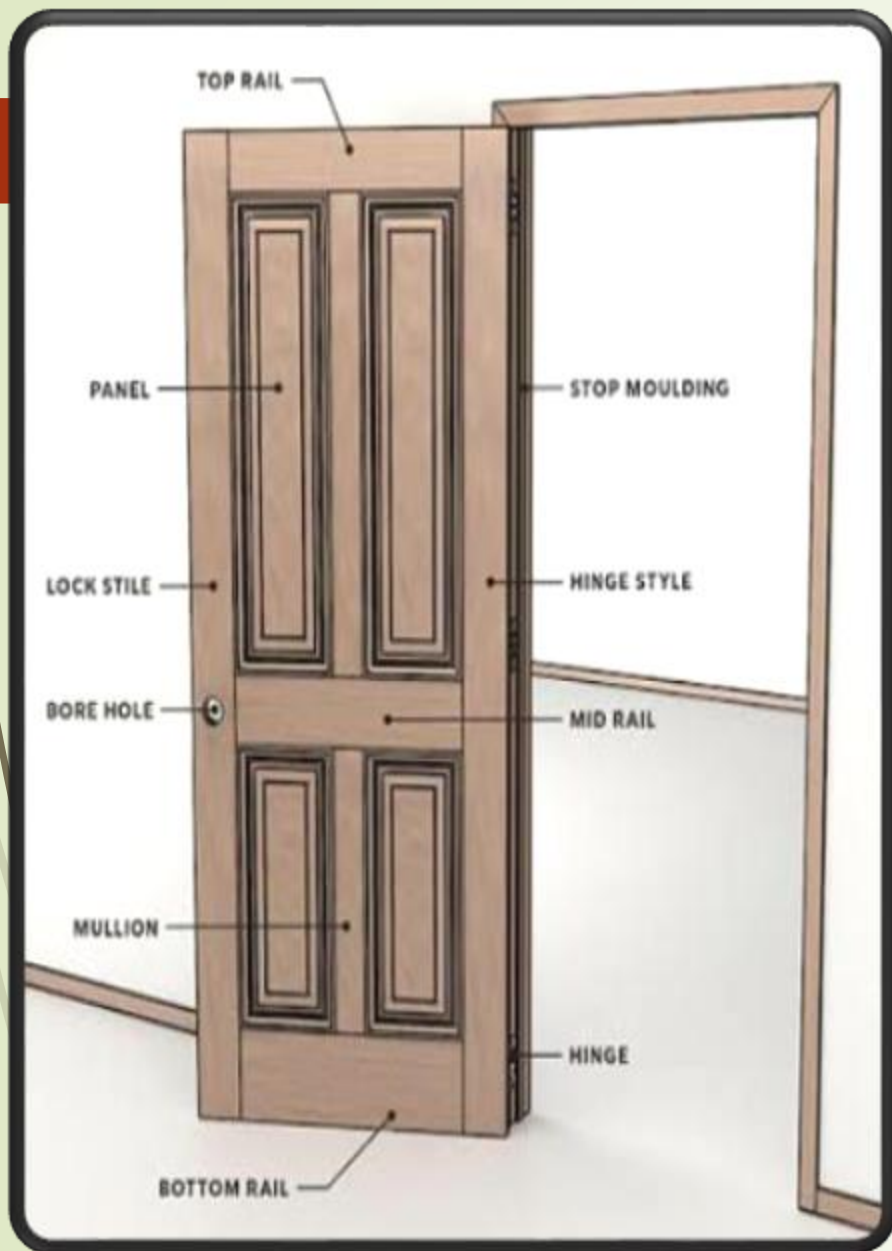
16. **Rebate** - It is a depression cut in the frame to accommodate door.

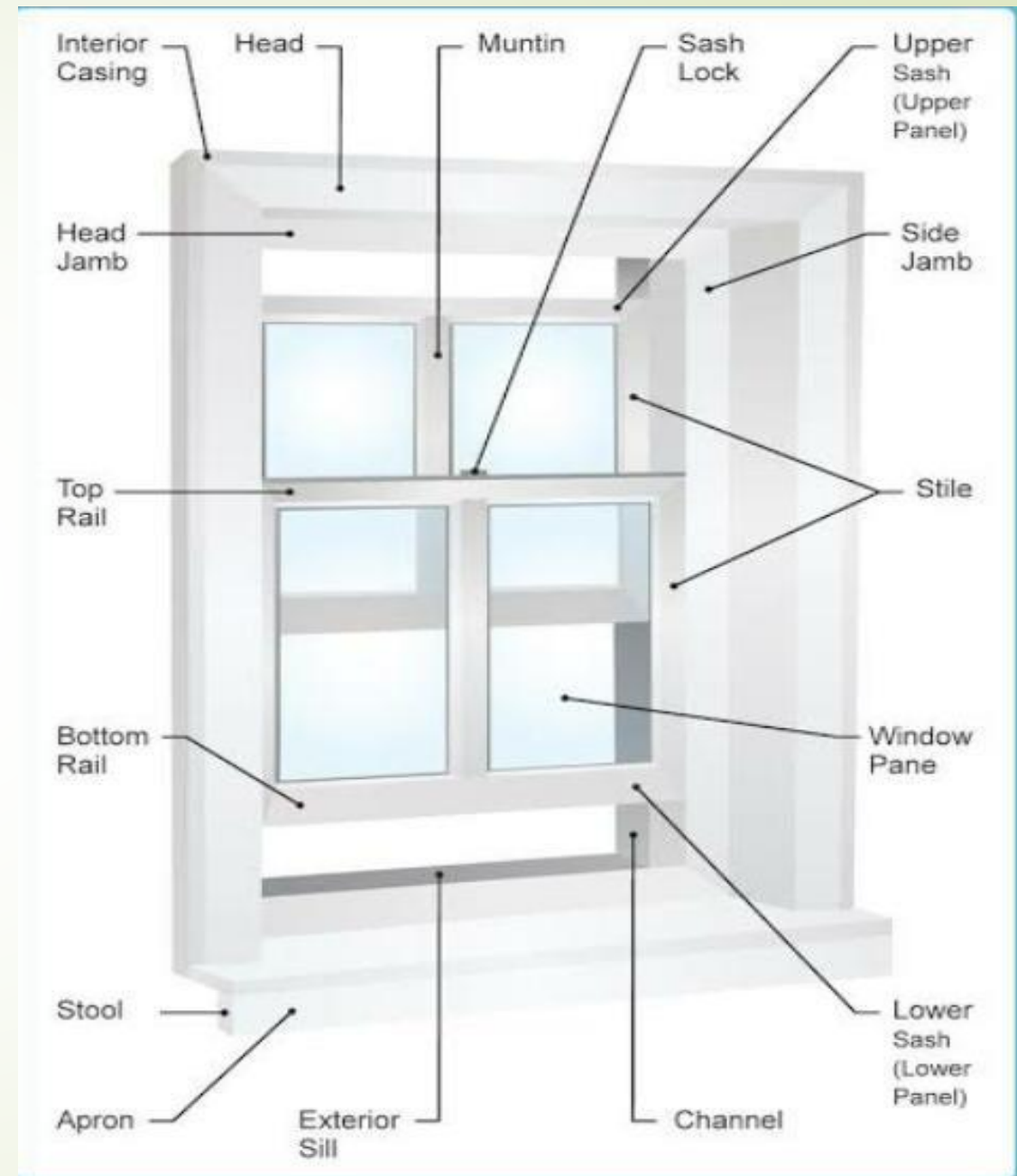
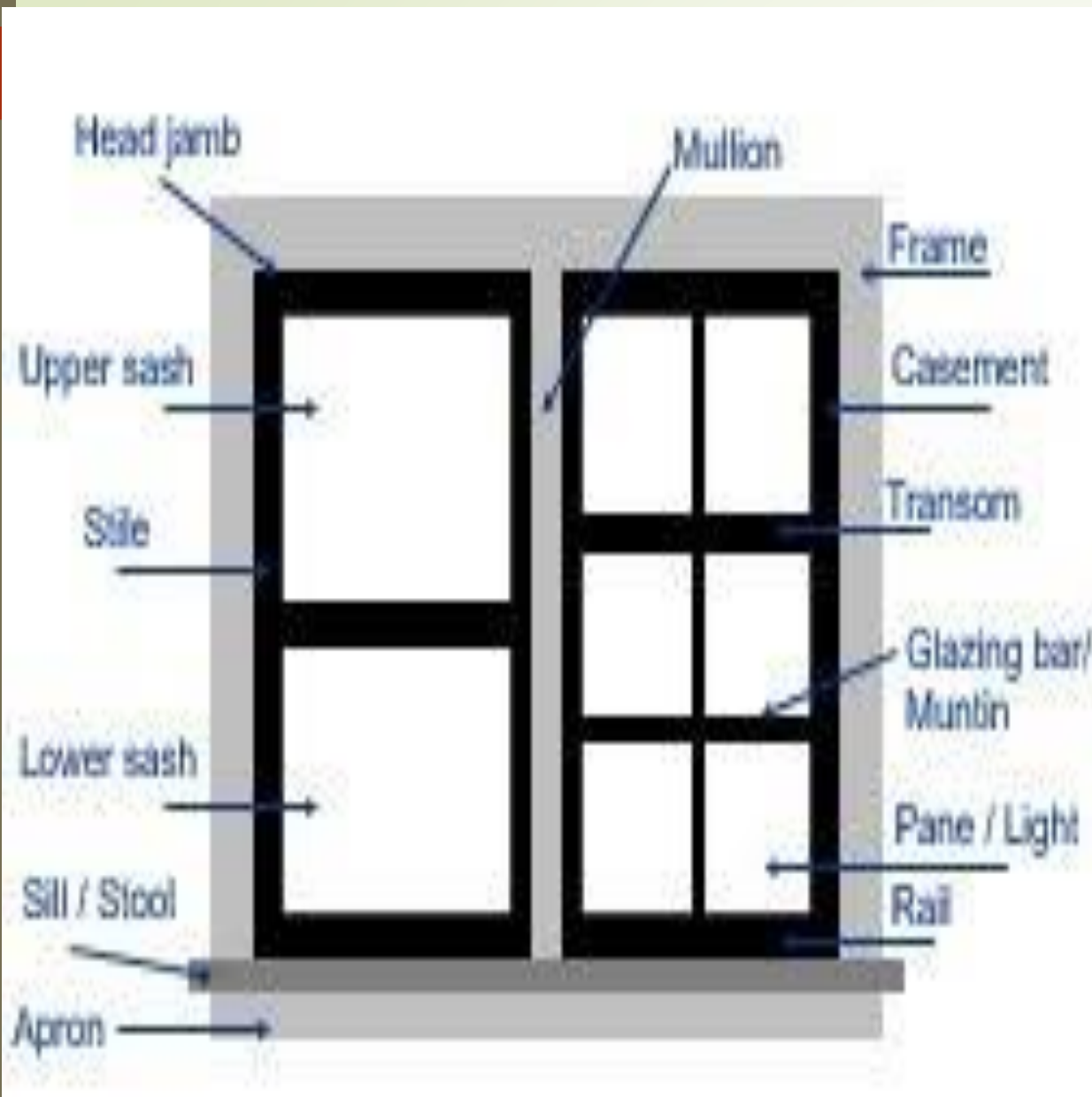


Door



EXTERIOR VIEW





Types of doors

- Ledged door
- Ledged and braced door
- Ledged and framed door
- Ledged, Braced and Framed door
- Frame and paneled door
- Glazed or sash door
- Louvered door
- Flush door
- Revolving door
- Collapsible door
- Sliding door
- Rolling steel door
- Automated door



Ledged Door

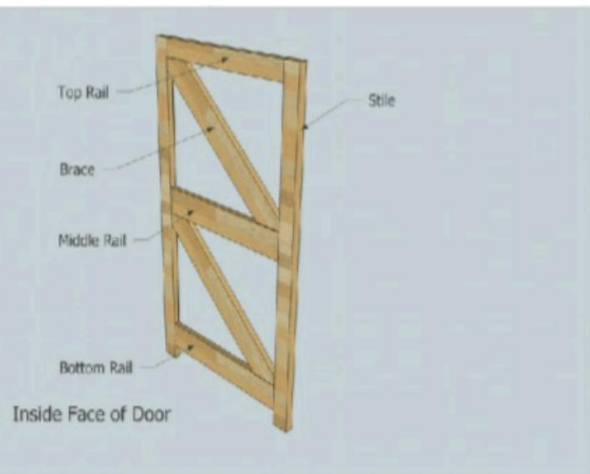
- Made up of timber boards known as battens
- Battens are placed vertically and fixed by horizontal ledges
- Two or Three ledges are provided in a door



Ledged and Braced Door

- Diagonal timber members are used – Braces
- These types of doors are more rigid
- Can be used as wide openings

10-15 cm wide and 30mm thick



Ledged door

Ledged Door



ledged and braced door

Ledged and Braced Door

Ledged and Framed Door

- Framework for the shutter is provided
- Strong and has a good appearance

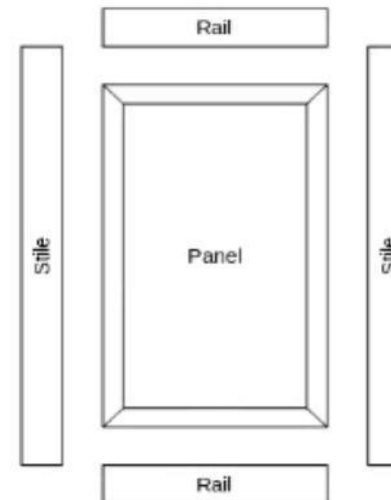
10 cm wide and 4cm thick →
(style)



Frame and paneled Door

- The number of panels depends upon
 - The size of the door
 - Appearance
- Minimum width of
 - Style – 10 cm
 - Lock rail/ Bottom rail – 15 cm

Frame and paneled Door



Glazed and Sash Door

- Used when more light is required besides that coming from the windows
- Generally glazed portion to paneled portion is 1:1 or 2:1



Louvered Door

- Allows sufficient amount of ventilation
- Maintains privacy as well
- Louvers are arranged such that upper back edge of any louver is above or lower front edge of the next higher louver

The shutter is provided with a fixed louver or a movable louver



Louvered Door



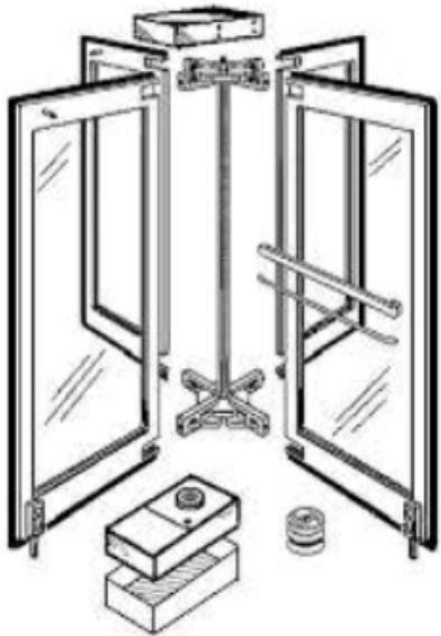
Flush Door

- Very strong and it is sound proof to a great extent
- Has a smooth and clean surface
- Both the faces of the framework are covered by 0.6 cm plywood



Revolving Door

- Used to regulate the entry of persons in big hotels, banks, theaters, hospitals



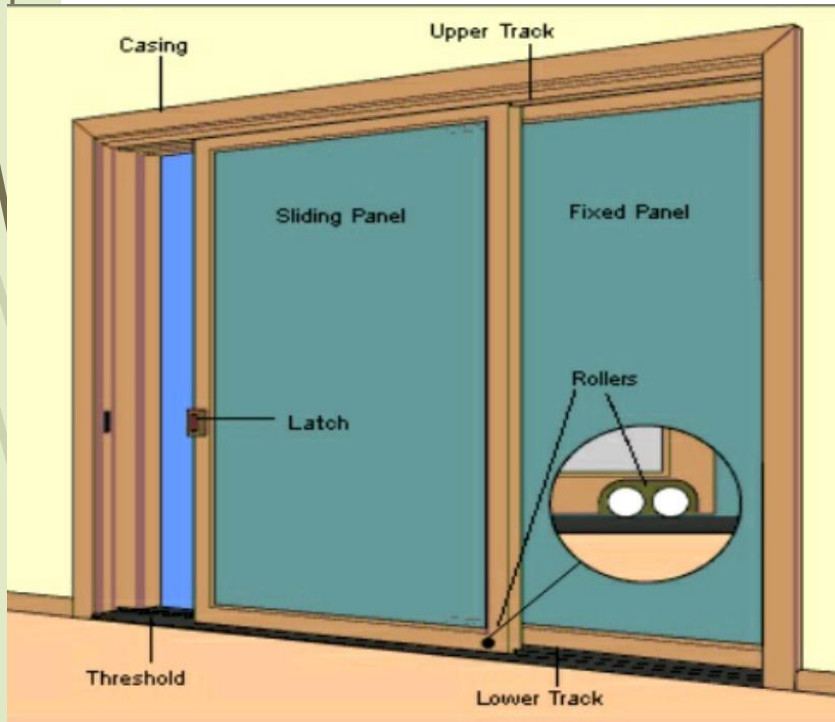
Collapsible Door

- Made of thin mild steel sections
- Used in shops, go downs, schools, workshops, public buildings



Sliding Door

- The shutter slides with the aid of runners and guide
- Commonly used in shops, show rooms, go downs etc



Rolling steel Door

- Commonly used for show windows, shops, store, offices etc.
- The door shutter moves up and down in steel guides
- The weight of the door is counter balanced by helical spring provided in the drum
- A steel cover is provided to protect the drum from weathering

Rolling Steel Door



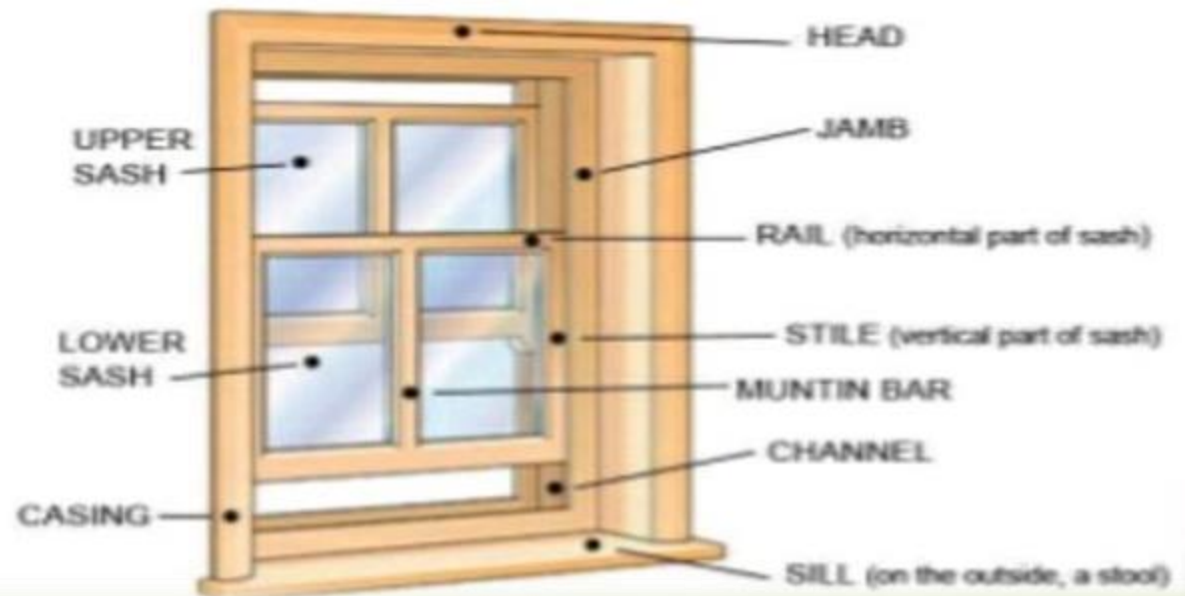
Automated Doors

- Use sensors to identify people from some distance and doors are automated to open accordingly



Windows

- ❑ A window is a transparent or a translucent opening in a wall or door that allows the passage of light and, if not closed or sealed, air and sound.
- ❑ Windows are held in place by frames, which prevent them from collapsing in.





Types of Windows used in Buildings

There are so many types of windows are available based on their positions, materials, and functioning. Windows are classified as follows.

- Fixed windows
- Sliding windows
- Pivoted windows
- Double-hung windows
- Louvered windows
- Casement windows
- Metal windows
- Sash windows
- Corner windows
- Bay windows
- Dormer windows
- Clerestory windows
- Lantern windows
- Gable windows
- Ventilators
- Skylights



1. Fixed Windows

- Fixed windows are fixed to the wall without any closing or opening operation. In general, they are provided to transmit the light into the room. Fully glazed shutters are fixed to the window frame. The shutters provided are generally weatherproof.

2. Sliding Windows

- In this case, window shutters are movable in the frame. The movement may be horizontal or vertical based on our requirements. The movement of shutters is done by the provision of roller bearings. Generally, this type of window is provided in buses, bank counters, shops, etc..

3. Pivoted Windows

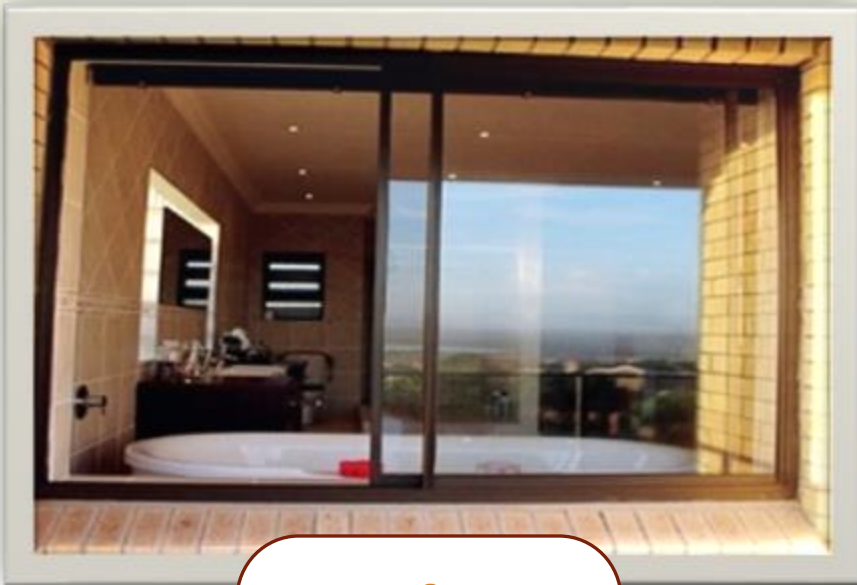
- In this type of windows, pivots are provided to window frames. Pivot is a shaft which helps to oscillate the shutter. No rebates are required for the frame. The swinging may either horizontal or vertical based on the position of pivots.

4. Double Hung Windows

- Double hung windows consist of pair of shutters attached to one frame. The shutters are arranged one above the other.
- These two shutters can slide vertically within the frame. So, we can open the windows on top or at bottom to our required level.



1



2



3



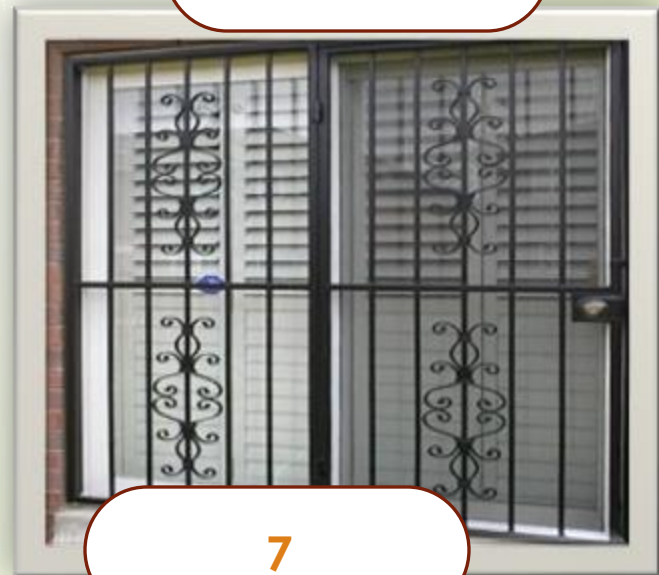
4



5



6



7

5. Louvered Windows

- Louvered windows are similar to louvered doors which are provided for the ventilation without any outside vision. The louvers may be made of wood, glass or metal.
- Louvers can also be folded by provision of cord over pulleys. We can maintain the slope of louvers by tilting cord and lifting cord.

6. Casement Windows

- Casement windows are the widely used and common windows nowadays. The shutters are attached to frame and these can be opened and closed like door shutters.
- Rebates are provided to the frame to receive the shutters. The panels of shutters may be single or multiple. Sometimes wired mesh is provided to stop entering of fly's.

7. Metal Windows

- Metal windows, generally mild steel is used for making metal windows. These are very cheap and have more strength. So, now days these are widely using especially for public buildings, private building etc.
- Some other metals like aluminum, bronze, stainless steel etc. also used to make windows. But they are costly compared to mild steel windows. For normal casement windows also, metal shutters are provided to give strong support to the panels.



8



9



10



11



12



13

8. Sash Windows

Sash window is type of casement window, but in this case panels are fully glazed. It consists top, bottom and intermediate rails. The space between the rails is divided into small panels by mean of small timber members called sash bars or glazing bars.

9. Corner Windows

- As in the name itself corner windows are provided at the corners of room. That means corner windows has two faces in perpendicular directions. By providing this type of windows, light or air can be entered into room in two different directions.
- To provide this type of window special lintel is provided in the wall. Corner windows will give aesthetic appearance to the building.

10. Bay Windows

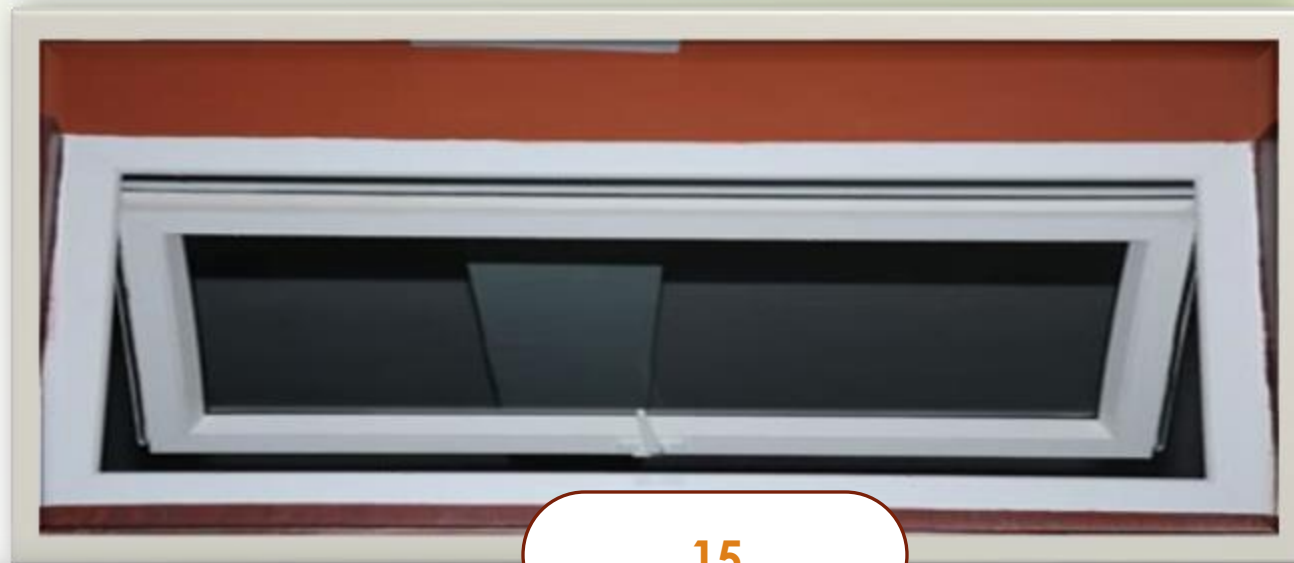
- Bay windows are projected windows form wall which are provided to increase the area of opening, which enables more ventilation and light form outside.
- The projection of bay windows are of different shapes. It may be triangular or rectangular or polygonal etc. They give beautiful appearance to the structure.

11. Dormer Windows

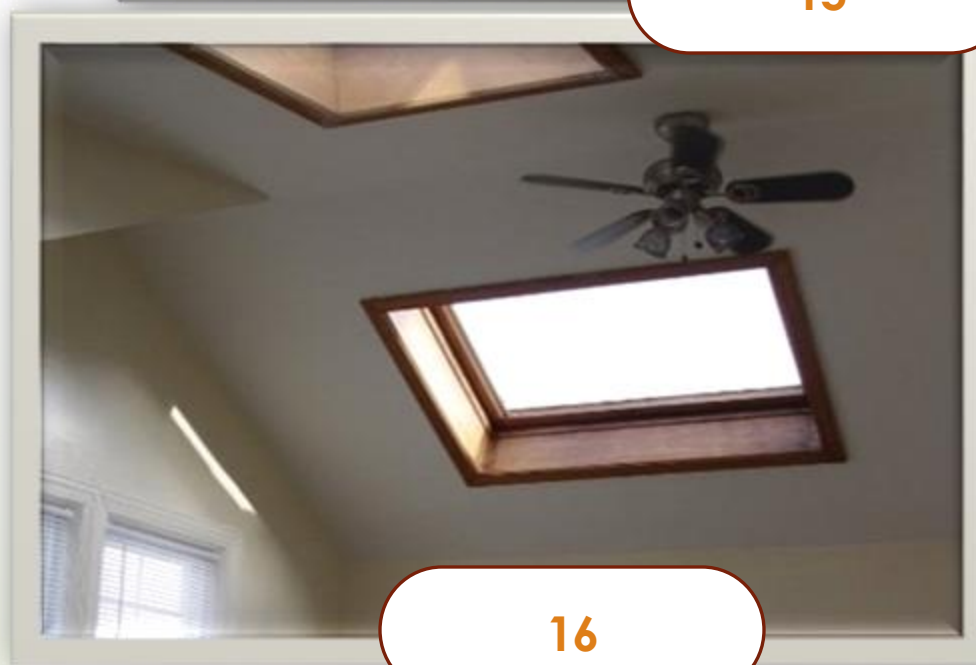
- Dormer windows are provided for sloped roofs.
- These are projected from the sloping surface as shown in below image. They provide ventilation as well as lighting to the room. They also enhance aesthetic sense of room.



14



15



16

12. Clerestory Windows

- If the rooms in a building are of different ceiling heights, clerestory windows are provided for the room which has greater ceiling height than the other rooms.
- The shutters are able to swing with the help of cord over pulleys. These also enhance the beauty of building.

13. Lantern Windows

- Lantern windows are provided for over the flat roofs. The main purpose of this window is to provide the more light and air circulation to the interior rooms.
- Generally, they are projected from the roof surface so, we can close the roof surface when we required.

14. Gable Windows

- Gable windows are provided for sloped roof buildings. These windows are provided at the gable end of sloped roof so; they are called as gable windows. They also improve the appearance of building.

15. Ventilators

- Ventilators are provided for the purpose of ventilation in the room. They are provided at greater height than windows nearer to roof level. It is in very small size.
- Horizontally pivoted shutters are provided for ventilators. Sometimes shutter is replaced by wired mesh, in this case sunshade is provided to prevent against rain water.

16. Skylights

- Skylights are generally provided on the top of sloped roofs. To admit light into the rooms, sky lights are provided. It is provided parallel to the sloping surface. Sky lights can be opened when we required. Lead gutters are arranged to frame to make it as waterproof.

Arches and lintel

1) Definition:

- **Arch:** Arch is one of the structure that consists of a curved top on two supports that holds the weight of something above it. (construction materials are wood, stone, steel, brick and concrete)
- **Lintel:** lintel is also a structure which is horizontally made up from Timber stone concrete or steel across the top of a door or window.

Now coming toward the function of above both terms.

2) Function:

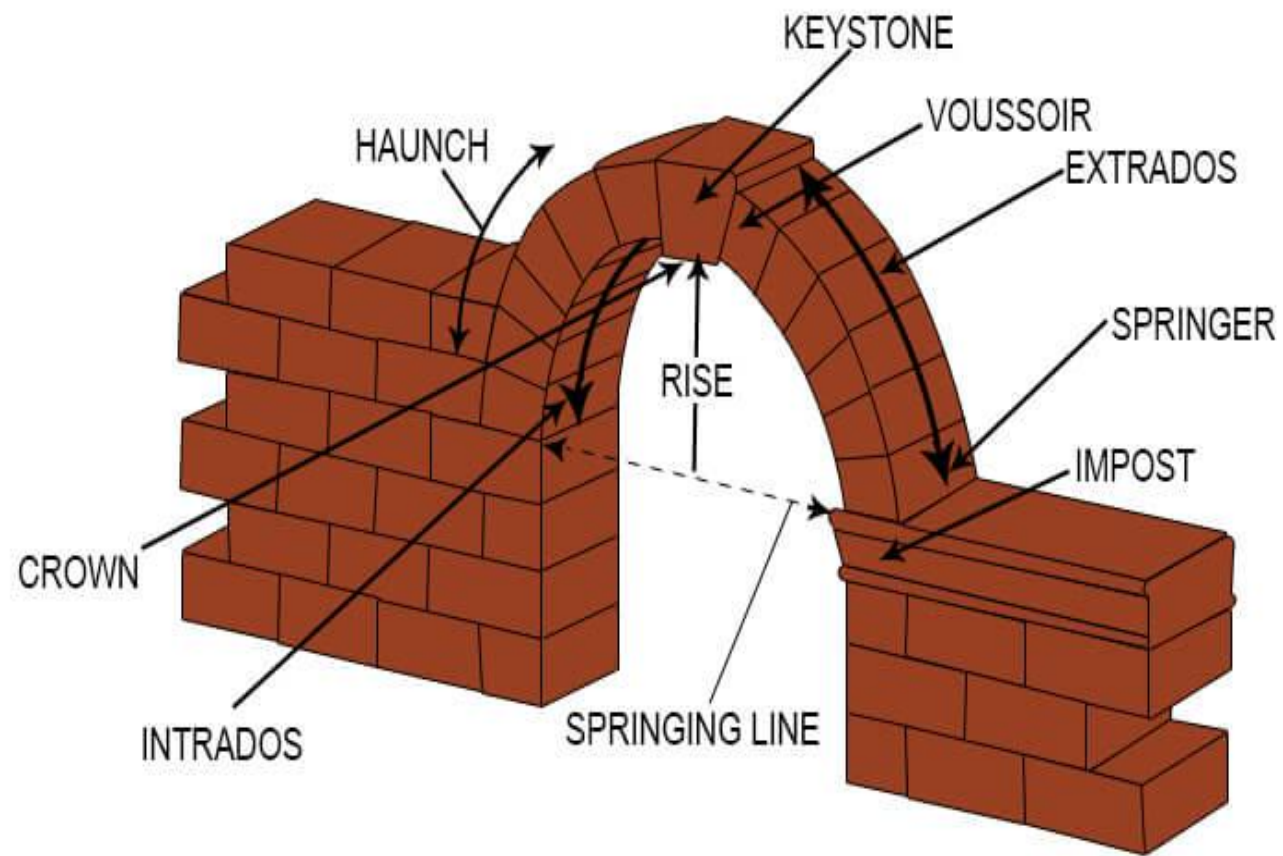
A) Arch :

- To sustain the weight of the structure above the opening
- In case of the arch, because of a special type of block, the blocks can support each other by providing mutual pressure of their own weight as well as the structure remain in positions by resistance from the support. A special type of centring devices are used for better finishing

B) lintel :

- Specially lintels are provided over windows are connected to a Sunshade to provide shade and shelter

Centring for lintel are much simpler as compare than that of the arch.



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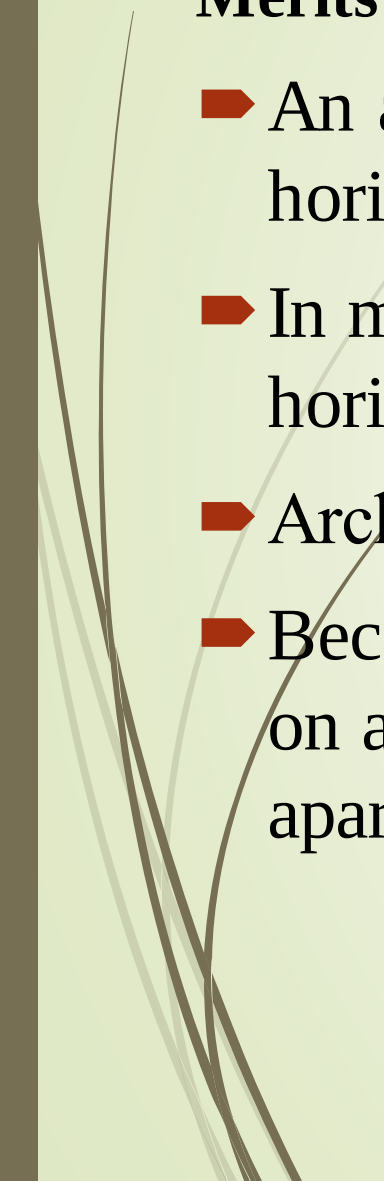
Without Arch



With Arch



Merits of Arch over lintel :

- An arch can definitely sustain a higher amount of load than usual, a horizontal beam can support
 - In masonry construction, Arches have great advantages over the simplest horizontal beam known as lintels.
 - Arches may rest on light supports but lintels can't.
 - Because of the higher loading capacity of Arch, the pressure downward on an Arc has the effect of forcing the voussoirs together instead of apart.
- 

FLOORS, ROOF, STAIRS

Floors, Roofs and Stairs

5.1 Floors: Glossary of terms ,Types of floor finishes – cast-in-situ, concrete flooring(monolithic, bonded), terrazzo tile flooring, cast in situ Terrazzo flooring, timber flooring (Concept only)

5.2 Roofs: Glossary of terms, Types of roofs, concept and function of flat, pitched, hipped and Sloped roofs

5.3 Stairs: Glossary of terms; Stair case, winder, landing, stringer, newel, baluster, rise, tread, width of stair case, hand rail, nosing, head room, mumty room.

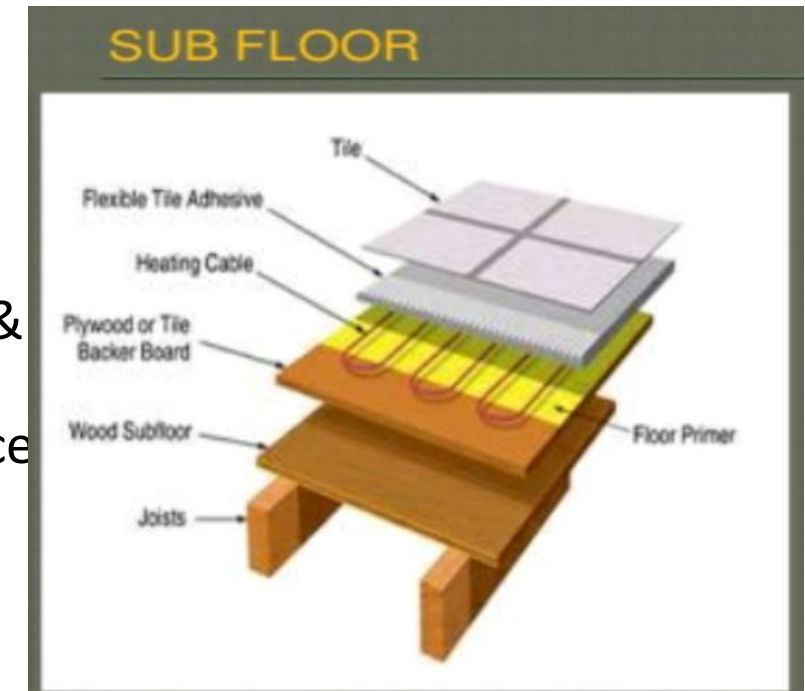
5.4 Various types of stair case – straight flight, dog legged, open well, quarter turn, half turn (newel and geometrical stairs), bifurcated stair, spiral stair, cantilever stair, tread riser stair.

- **Flooring** is the general term for a permanent covering of a floor, or for the work of installing such a floor covering.
- **Floor covering** is a term to generically describe any finish material applied over a floor structure to provide a walking surface. Both terms are used interchangeably but floor covering refers more to loose-laid materials.
- COMPONENTS OF FLOOR:
- The lower portion of floor structure consisting of beams, slabs, rammed earth etc. prepared to provide necessary support to the floor covering.
- Purpose:
To provide proper support to floor covering without sinking & settlement.

Floor Covering/ Paving:-

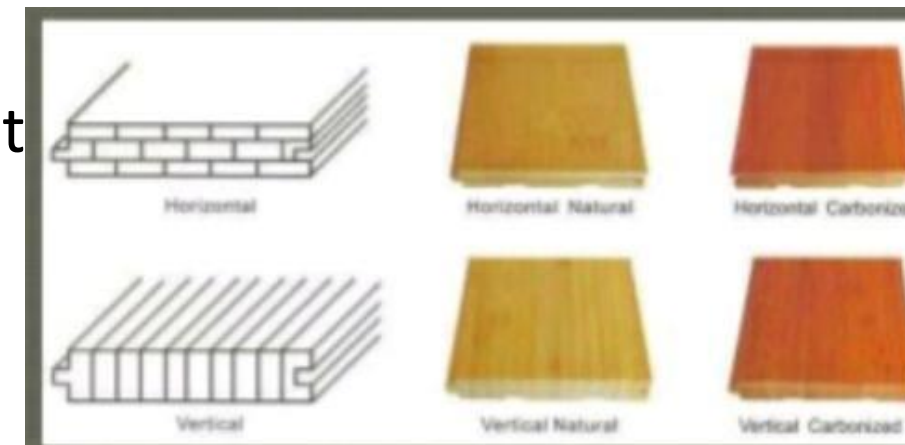
The upper portion of floor structure consisting of base, under layer & topping.

Purpose: To have clean, smooth, non absorbent and a durable surface. It also shall not be slippery, noisy and unpleasant in appearance.

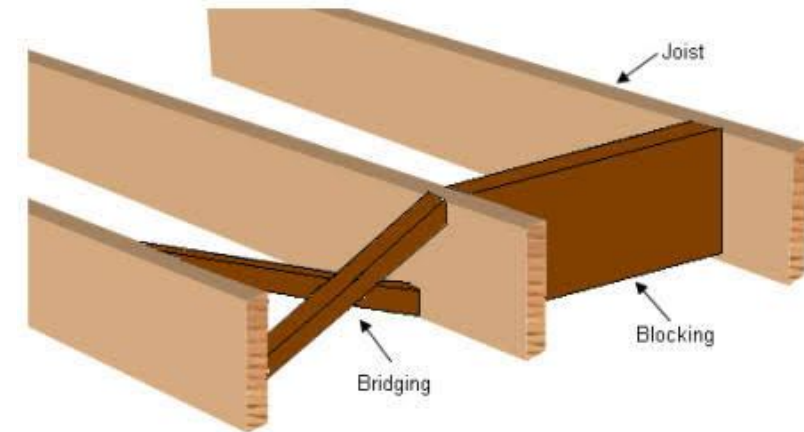


IMPORTANT TECHNICAL TERMS:

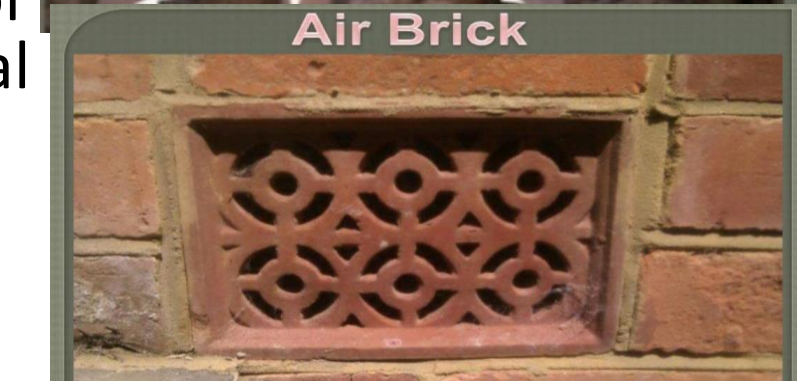
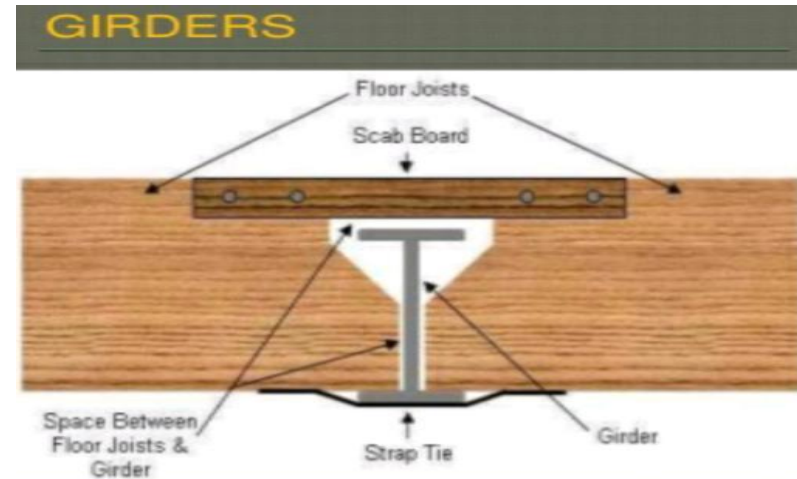
- **Base course:** Base is the prepared surface on which floor topping or under layer is laid. The layer of material provided for this purpose is known as Base course.
- **Under layer:** Layer of material provided in between the base & floor topping.
- **Topping:** Topmost layer of floor provided over the under layer / base course, in the absence of under layer.
- **Screeding:** The art of bringing the floor to a true and level surface by means of screeds.
- **Floor systems:** Arrangement provided to support the toppings of floor. It may be single, double or triple joist system.
- **Floor boards:** Wooden boards which form the floor toppings.



- **Floor finish:** Top surface of floor. Also known as "wearing surface"
- **Bedding:** A layer of mortar applied to the base or sub floor and brought to a prescribed level
- **Screeds:** Narrow strips of wood, bands of plaster or pieces of tiles laid on the floor to act as guides for bringing the toppings to a true even surface.
- **Bridging Joists:** Horizontal structural members placed along shorter spans immediately below floor toppings. They are used as main supporting members in timber floors.
- **Binders:** Horizontal structural members placed at right angles two bridging joists to take their load and that of floor toppings.



- **Girders:** Horizontal structural members placed to supports the load of binders, bridging joists and that of floor toppings. Used as main supporting member in a triple joist floor system.
- **Wall plates:** Horizontal wooden members which support one end of bridging joists and distribute the load from joist to the wall.
- **Sleeper/Honey comb brick wall:** Wall constructed with holes for free circulation of air in case of single joist wooden floor at ground level. This act as a dwarf wall and is generally constructed longitudinally in the middle of the room.
- **Air brick :-** A brick provided with holes for free circulation of air in the interior of wall or floor. They are placed in external wall of wooden ground floor.



GLOSSARY TERMS used in floor:-

Backing

- Backing is the bottom-most layer of a floor. When used with vinyl flooring, it can be made of felt or fiberglass. Carpet backing refers to the underside of carpet. It helps to extend the life of carpet
- **Back Layer**
- The back layer is the bottom layer or base of laminate flooring. It is typically made of a sturdy and moisture-resistant material, such as melamine.
- **Berber**
- Berber carpet is named for a type of woolen, textured carpet made by Berber tribes in Morocco and other parts of North Africa. The yarns on Berber carpet are in loops that connect directly to the backing. Berber carpet is known for being able to withstand a lot of foot traffic and for being easy to clean.
- **Carpet Pile**
- Carpet pile refers to the fibers on the top layer of carpet. Pile can be low, medium or high. A low-pile carpet has fibers that are less than 1/4-inch high.

- **Impact Resistance**

- Impact resistance refers to how well a type of material can withstand the force of items being dropped on it. A floor with a high impact resistance will continue to look good even if things are regularly dropped on it or dragged across it.

Marble

- Marble is a type of stone sometimes used as a material for flooring. Marble has a distinct appearance and usually features swirls or veins of color. It does tend to be more high-maintenance and more expensive than other flooring options. Imitation marble is available for people looking for the look and elegance of the stone without the cost and upkeep requirements.

Refinish

- Refinish means to add a new coat of finish to the top of a hardwood floor. The goal of refinishing is to minimize the appearance of scratches, scuff marks and other signs of damage.



TYPES OF FLOOR FINISHES:-

cast-in-situ flooring:-

- A suspended reinforced concrete **floor** can be either **cast** monolithically in position in a building or can be formed of a series of reinforced pre-**cast** concrete units, manufactured in a factory and brought to the site ready for building into position. The former method is referred to as being “**cast in situ**”.

Concrete flooring(monolithic, bonded):-

Cement Concrete Flooring is commonly used both in residential as well as public buildings.

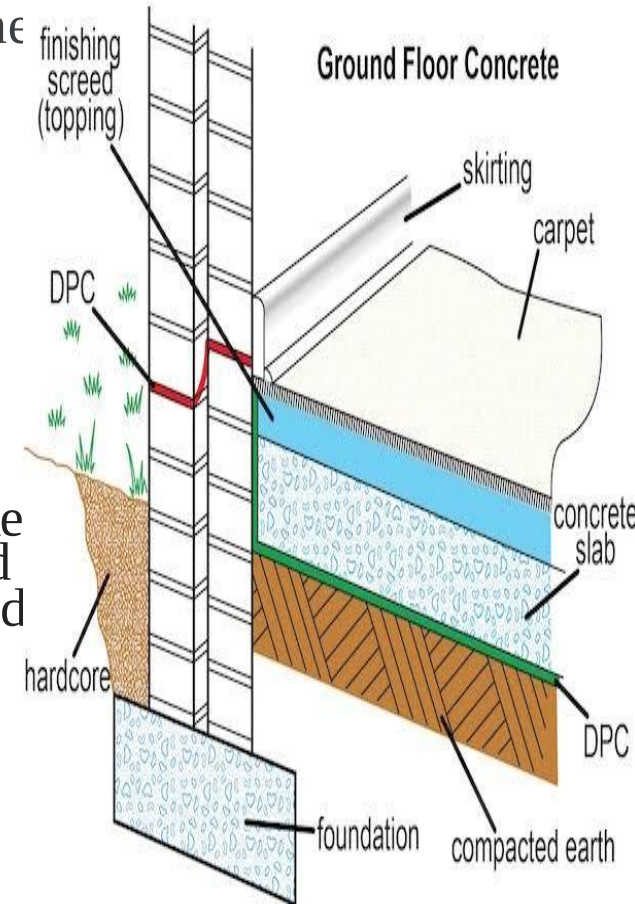
The method of laying **cement concrete flooring** on ground floor of a building can be broadly divided in the following steps.

(i) Preparation of sub-base:

The earth filling in plinth is consolidated thoroughly so as to ensure that no loose pocke are left in the whole area. A 10 to 15 cm. thick layer of clean coarse sand is then spread over the whole area. The sand layer a consolidated and dressed to the required level and slope.

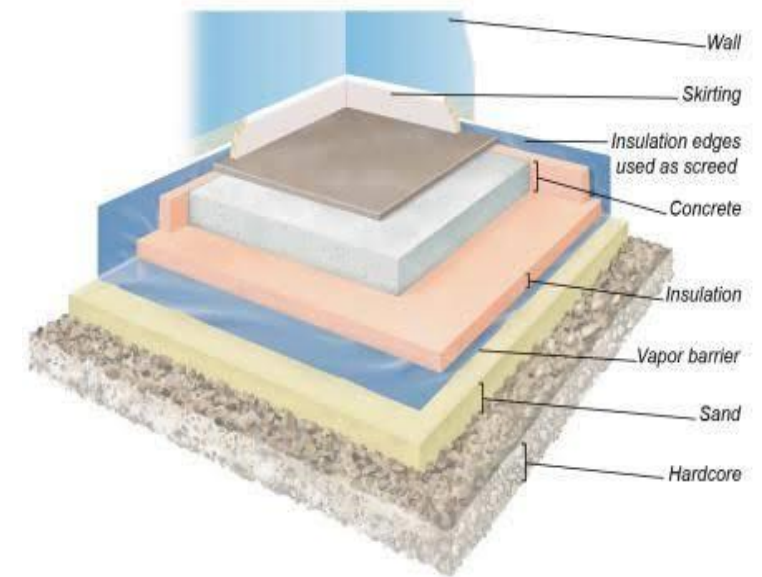
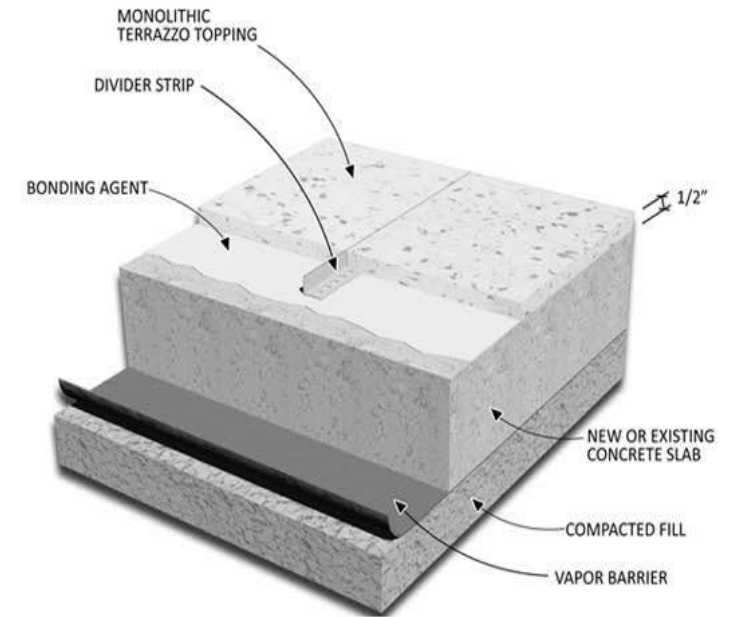
(ii) Laying of base concrete:

The base concrete used under floors may be cement concrete or lime concrete laid to a thickness varying from 75 to 10 cm. In case of **cement concrete**, the mix commonly used is 1:5:10 (1 cement: 5 sand : 10 stone or over burnt brick aggregates 40 mm. nominal size). Lime concrete, if used, should be made up out of 40 mm. nominal size stone/over burnt brick aggregate and 40% mortar comprising of 1 lime : 2 sand/surkhi or 1 lime : 1 surkhi/ash : 1 sand. The base concrete layer is deposited over the whole area, thoroughly lamped and levelled to a rough surface.



(iii) Laying the topping:

- When the base concrete layer has fully set and hardened, its surface is thoroughly cleaned and the entire area is divided into rectangular or square panels by use of 4 mm, thick glass strips or 5 mm, thick plain asbestos strips.
- The surface of base concrete should be made damp and applied with a coat of neat cement slurry prior to laying the topping., The rough finished surface of base concrete coated with cement slurry ensures adequate bond between the base and the topping.
- The cement concrete topping, normally consisting of 1:2:4 (1 cement :2 sand : 4 stone aggregate) is then laid in required thickness in one operation in the panels.
- The concrete is spread evenly by using a straight edge and the surface is thoroughly tamped and floated with wooden floaters till the cream of the mortar comes at top.



1. In order to prevent the tendency of separation of the cement concrete flooring from the R.C.C. slab, a 20 mm. thick cushioning layer of lime mortar (1 lime : 2 sand/surkhi or/lime : 1 surkhi/sand) or 50 to 75 mm. thick lime concrete is sometimes provided between the R.C.C. slab and the ***cement concrete flooring***.
2. If the working conditions permit, the flooring can also be laid monolithically over the R.C.C. slab while the slab concrete is still green. In this case, the slab concrete is roughened with wire brushes so as to ensure a good bond between the base and the flooring layer. Prior to laying of flooring, the slab surface is cleaned and a coat of cement slurry is applied over it. In this case, any slope required for the floor is given in structural concrete itself.





2. Terrazzo tile flooring:-

Terrazzo flooring is composed of composite material. It contains any variety of mixture of aggregate chips like stone or marble and either epoxy resin or concrete. It can be used both indoors and outdoors and can be poured as concrete or laid in tiles

ADVANTAGE OF TERRAZZO FLOORING:-

Terrazzo floors are among the easiest to clean: There's no scouring, polishing or scrubbing.

- The customization option is limitless for terrazzo floors.
- The speckled texture and strong base material make them difficult to stain.
- When terrazzo flooring is properly sealed, it is non-porous and resistant to mold
- Because it is made up of sturdy materials like cement, terrazzo is highly durable, which is why it is used so often in institutional and commercial buildings.
- Elegant and timeless, with endless design possibilities,



Terrazzo Cast in situ flooring:-

Procedure of Laying In-situ Terrazzo Flooring

1. Mixing of MaterialsI.

- To achieve a uniform appearance, it is essential to mix the materials thoroughly.
- It is recommended to mix the chips well in the required proportions of various colors and sizes when different colored chips are used.

Under-Layer of Terrazzo Flooring

- The cement concrete of the design mix shall be used, as discussed in the above design mix heading. The panels shall be of uniform size, not exceeding two sqm in area or two m in length for inside situations.
- In exposed situations, the length of any side of the panel shall not be more than 1.25 meters. Cement slurry at 2.00 kg per sqm shall be applied before laying of underlayer over the cement concrete / RCC base.

Fixing of Strips

- A 4 mm thick glass strips or 5 mm thick plain asbestos sheet or 2 mm thick PVC strips/aluminum strips /brass strips shall be fixed with their top at the proper level to required slope.
- The strips of stone or marble or any other material of specified thickness can also be used if specifically required.

Laying of Topping Layer of Terrazzo Flooring.

- All the topping materials, coloring material, cement, marble powder, and marble chips are dry mixed thoroughly.
- The dry mortar is then mixed with water by adding the water in fine sprays till the mortar is homogeneous, stiff, and workable.
- The terrazzo topping must be laid when the underlayer is sufficiently hard enough to prevent the cement from traveling to the surface, and the underlayer is still plastic. The topping layer shall be slightly more in thickness than that specified to achieve uniform thickness after compacting.
- The surface shall be brought to the required thickness by trowelling and pressing with the help of a straight edge and steel floats. It must be carried out in such a manner that the maximum amount of marble chips are visible and evenly spread over the surface.

Polishing, Curing and Finishing of Terrazzo Topping Layer

- The polishing of topping layer shall be strictly carried out by machine means after 36 hours of laying the top layer.
- The surface shall be watered and ground evenly with machine fitted with special rapid cutting grit blocks of coarse grade till the marble chips are evenly exposed, and the floor is smooth.

- **TIMBER FLOORING:-**

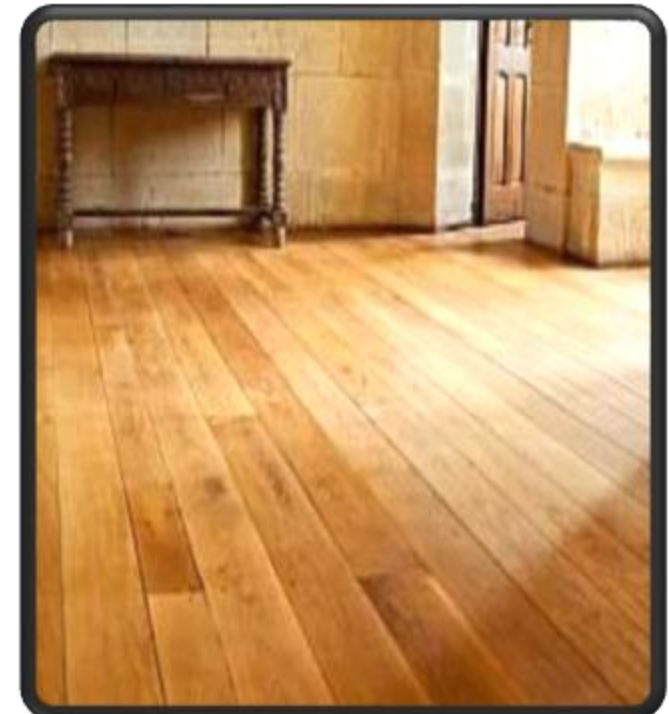
What is Timber ?

- Simply the name suggest that the flooring made of timber i.e wood is called timber fboring.

Wood is a common choice as a flooring material due to its environmental profile, durability, and restorability.

Why Timber ?

- Long lasting i.e more durablity.
- Easy to clean.
- Easy to resurface.
- Soft for foots unlike concrete and tiles.
- Gives better look.
- Low maintainence.
- Soft for falling objective



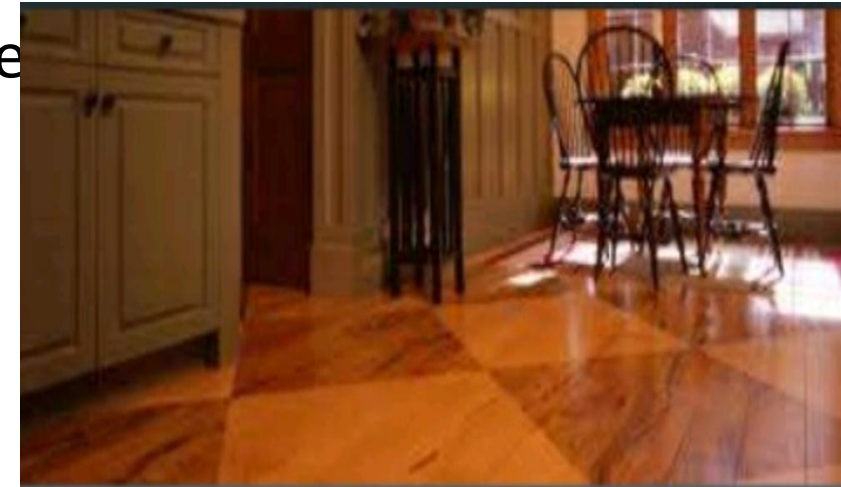
- **Strip flooring**

They are narrow and thin strips of timber jointed by tongue and groove joints. Normal strips 6 to 10 cm in width and 2 to 2.5 cm in thickness are used.



- **Wood block flooring**

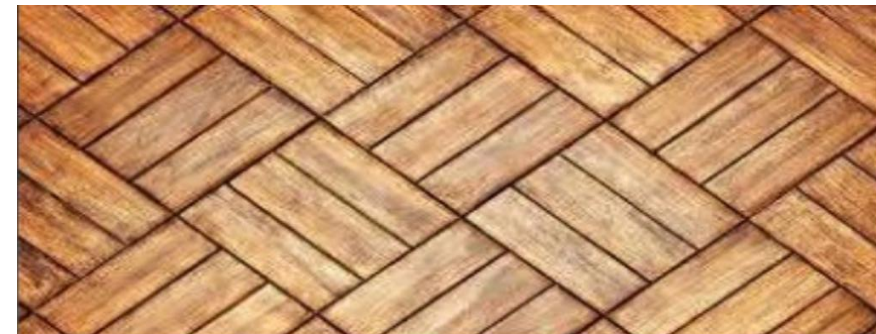
This consists of short but thicker wood blocks which are laid in suitable designs over a concrete base. These blocks are properly joined together with the grains exposed. Size varying from 200 mm x 80 mm to 300 mm x 80 mm, thickness 2 to 4 cm are used.



- **Parquet flooring**

This is similar to block flooring except thin blocks are supported on sub-floors. The blocks are laid by means of glue in desired pattern and then nailed with panel pins.

Popular in these days

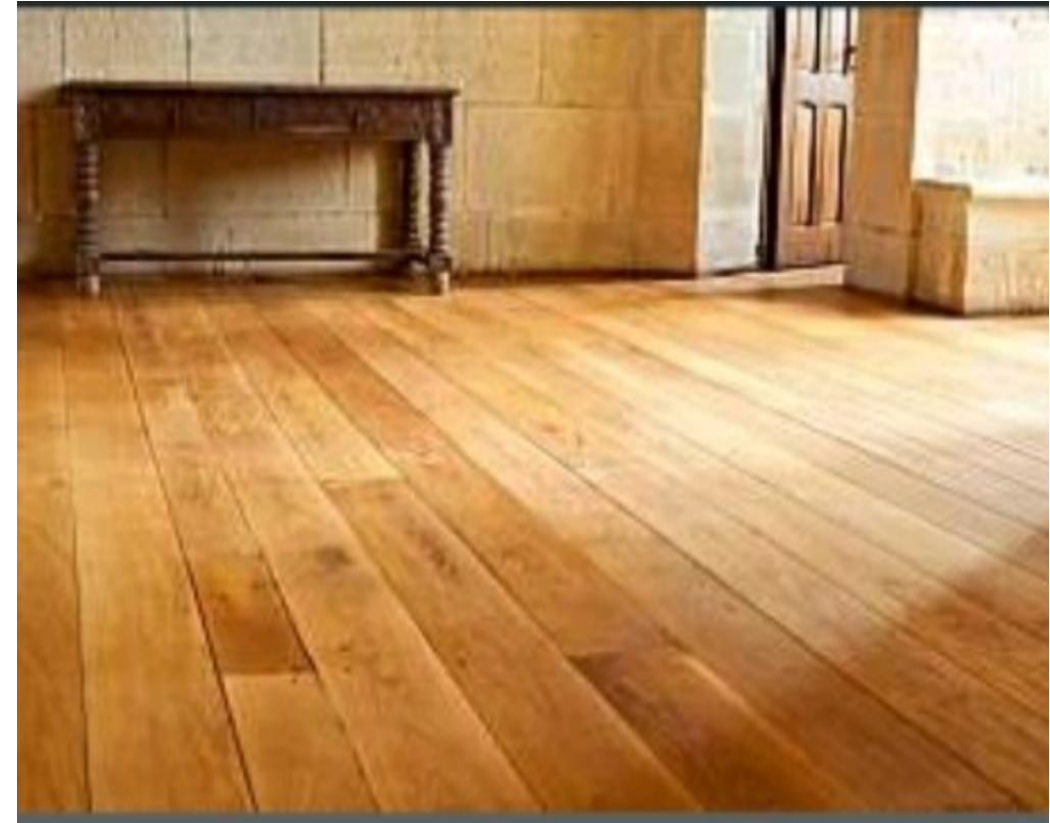


- ***Plank flooring***

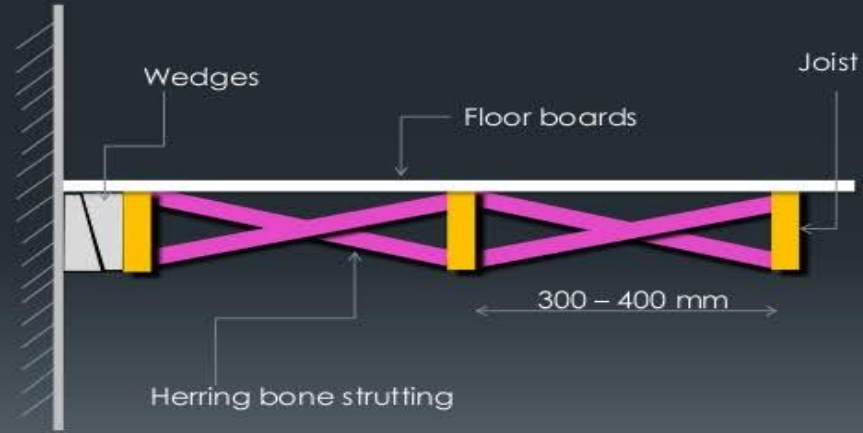
In this type of flooring wider planks are used Jointed by tongue and grooves.

- ***Single joist Timber flooring:-***

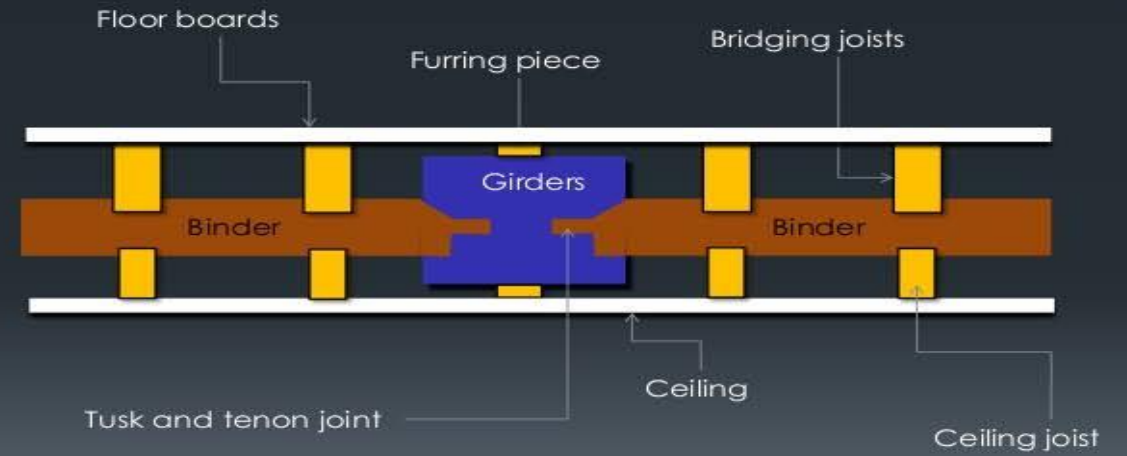
- This is the simplest type of timber floor used for residential buildings, where spans are short or moderate (say up to 4 m) and loads are comparatively lighter
- All joists require supporting at their ends and, in case of ground floor joists, at intermediate points along their length.
- The use of these intermediate supports reduces the clear span so that joists of smaller section can be used.
- For ground floor joists, the distance between these intermediate supports ranges from 1 Sm to 2.0m.
- Joists should have a minimum bearing point of not less than 90mm at any



SECTION ON AB

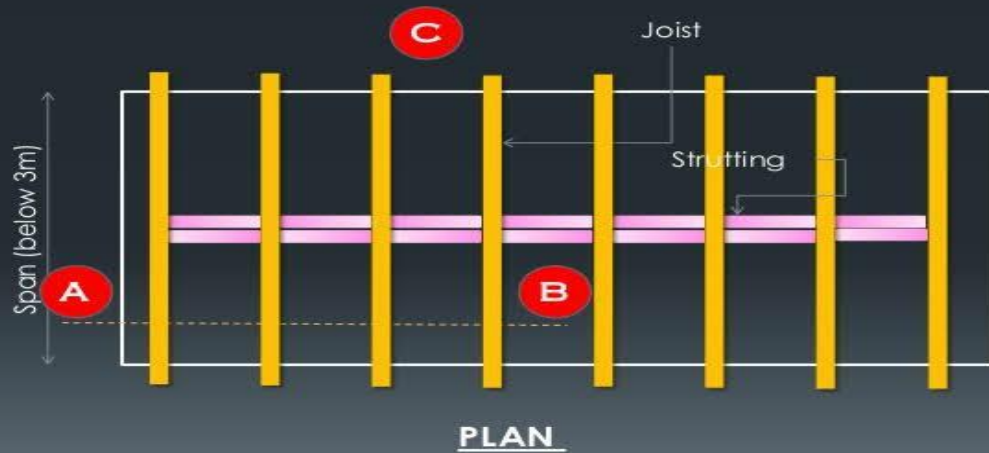


DETAILS OF FRAMED TIMBER FLOORS



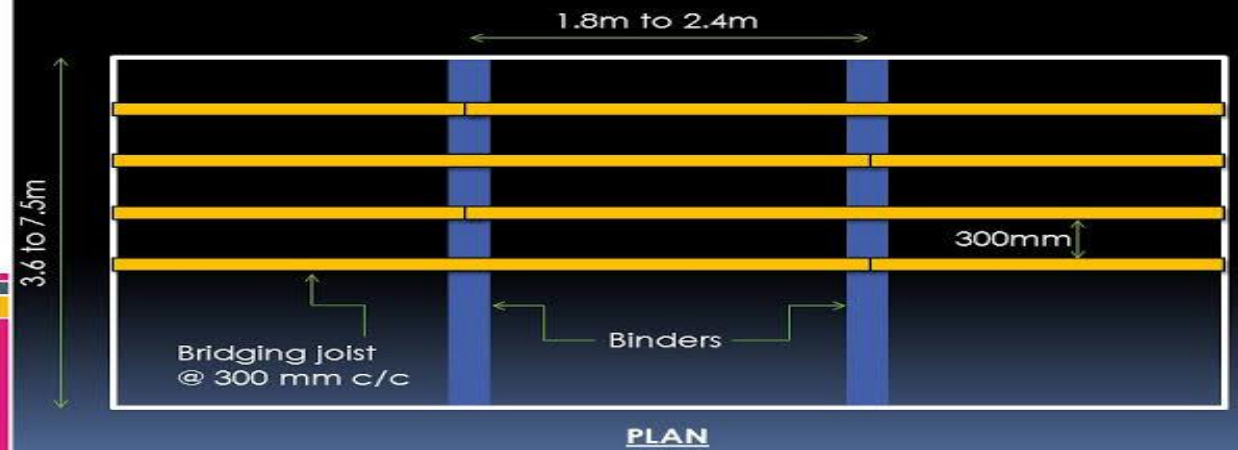
SINGLE JOIST TIMBER FLOORS

2



DOUBLE JOIST TIMBER FLOORS

3

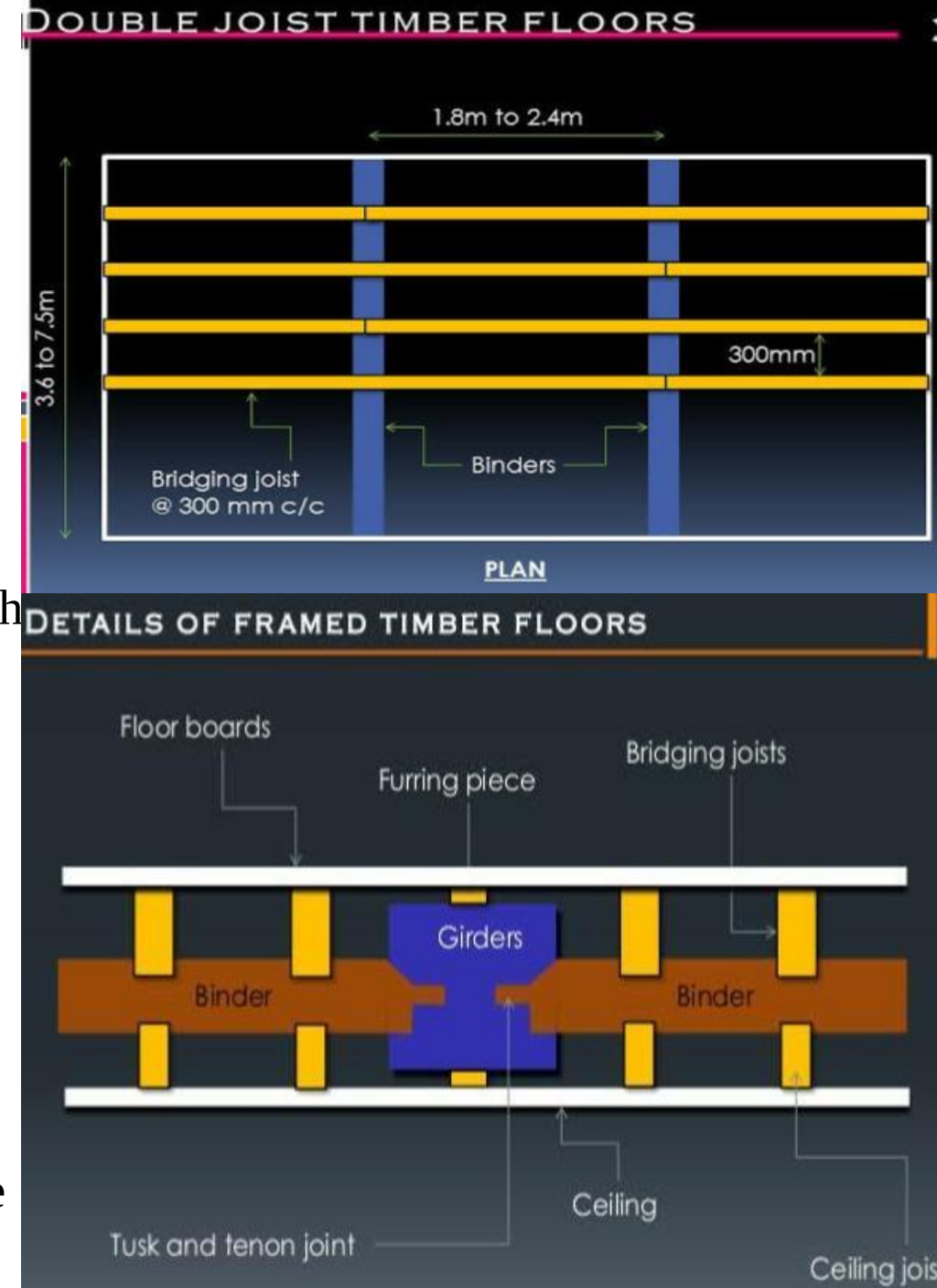


2. DOUBLE JOIST TIMBER FLOOR:-

- Intermediate supports known as binder, are provided for bridging joist.(C/C 1.80m to 2.40m)
- Stronger than single joist timber floor
- Prevent passage of sound in a better way & suitable for a span upto 3.60 to 7.50m.
- Disadvantages:- due to use of binder height of floor increased and accordingly room height decreased.

3. Framed Or Triple Joists Timber Floor

- This type of floor is suitable for spans greater than 7.50 m, in which intermediate supports, known as girders are provided for the binders.
- There are four elements of flooring.
 - (i) floor boards,
 - (ii) bridging joists,
 - (iii) binders, and
 - (iv) girders.
- The bridging joists support the floor boards.
- The binders are staggered and connected to girders by tusk and tenon joints, to increase the rigidity of the floor and to decrease the overall depth of floor.



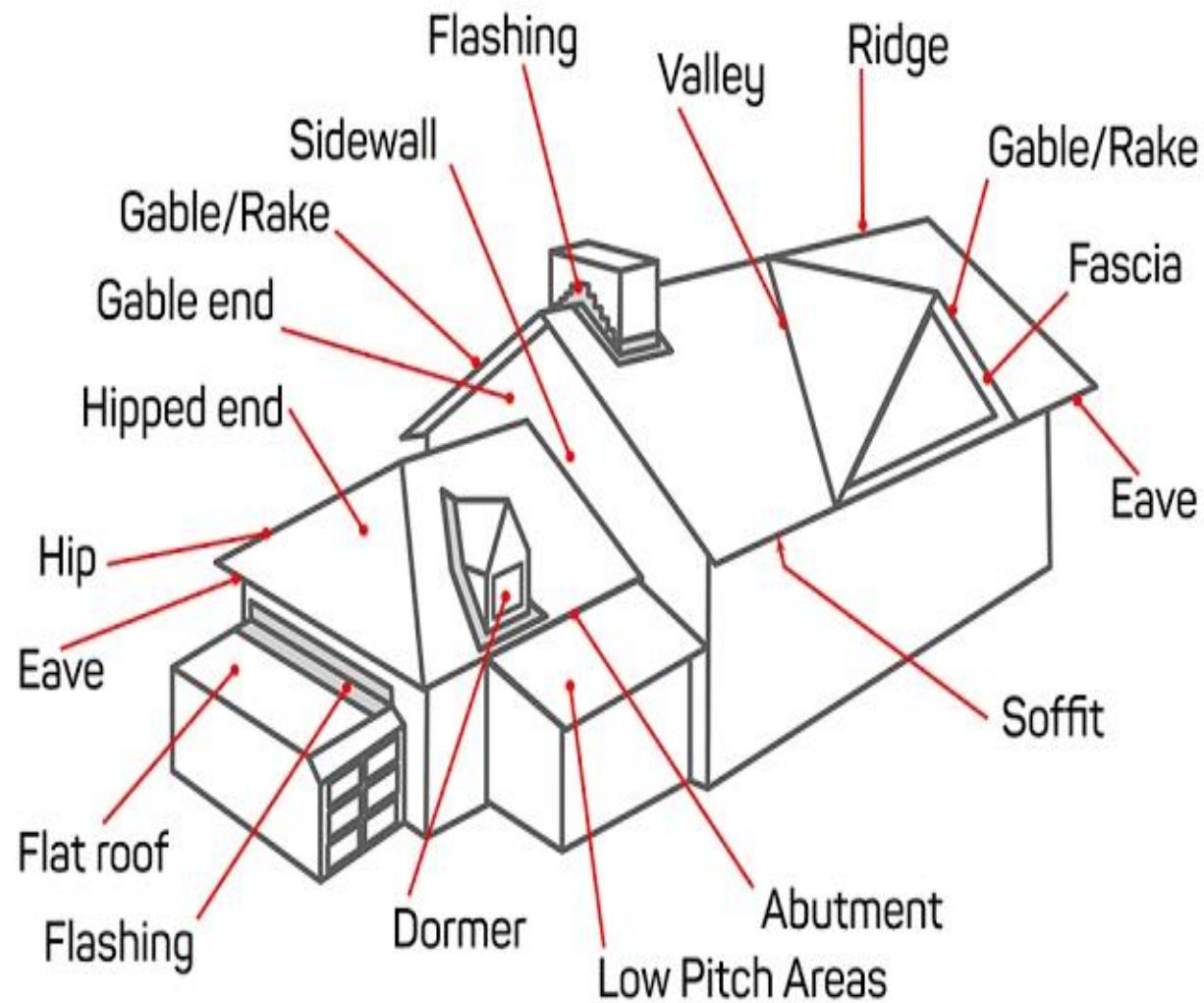
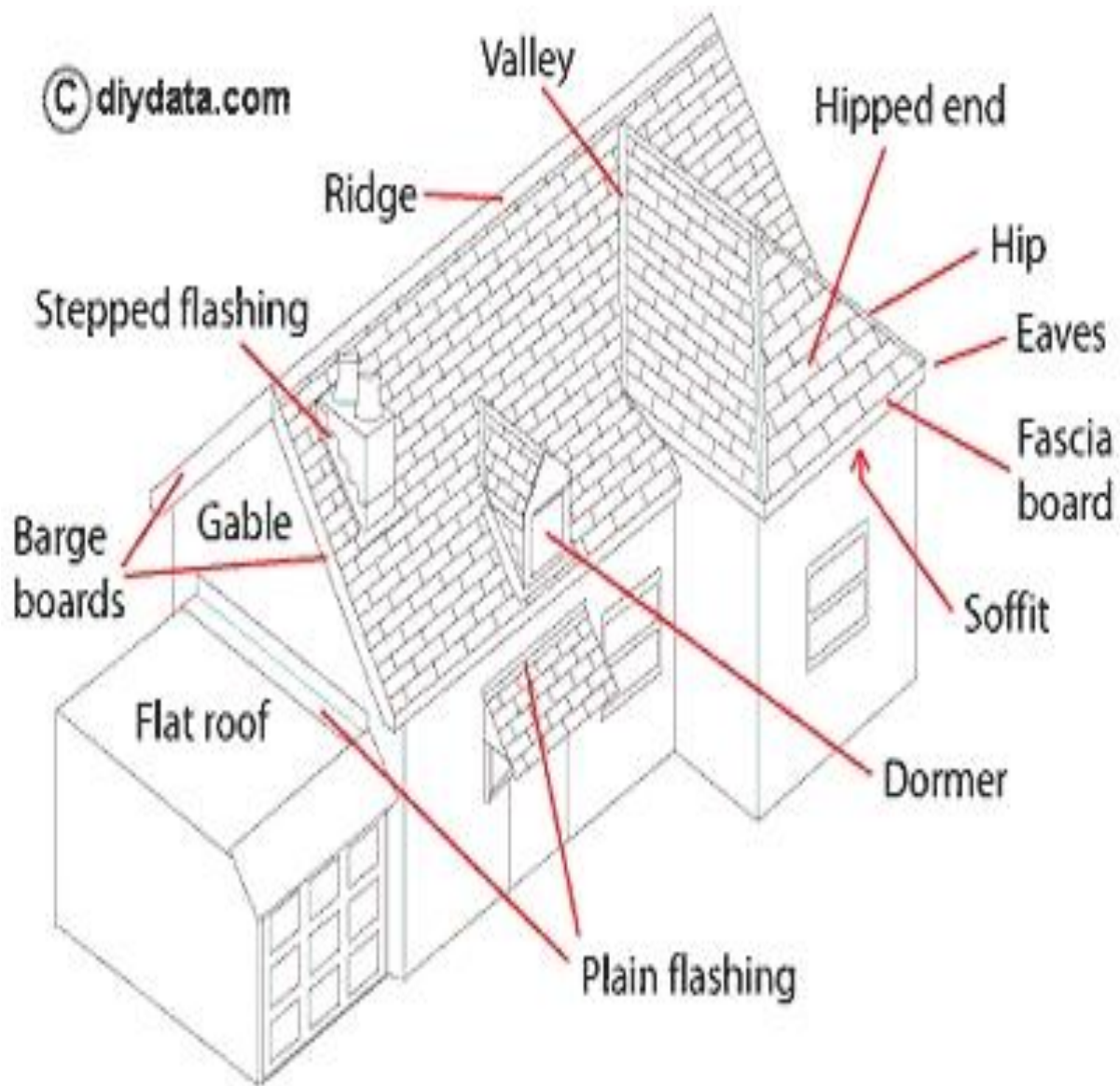
5.2 Roofs: Glossary of terms, Types of roofs, concept and function of flat, pitched, hipped and Sloped roofs

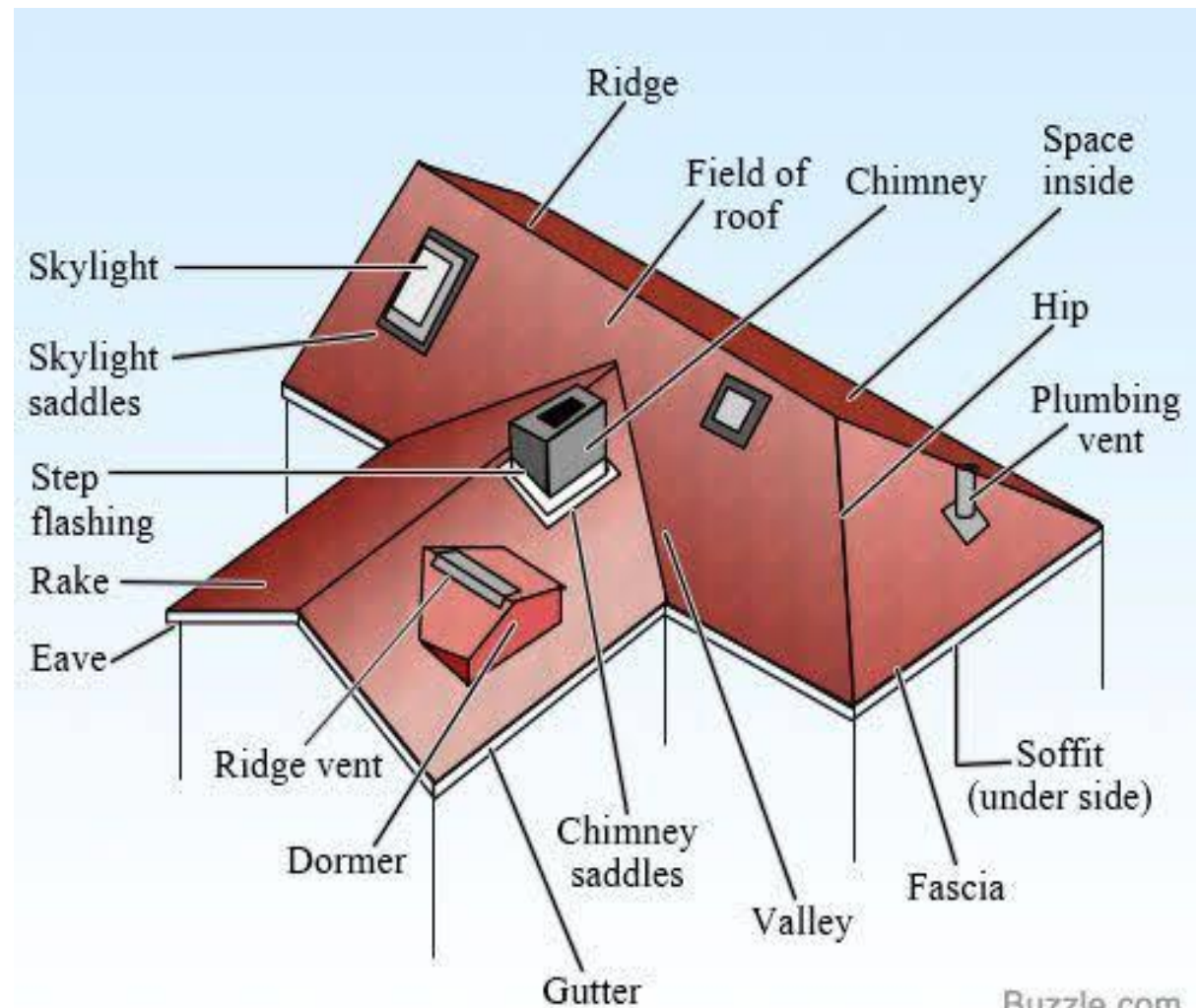
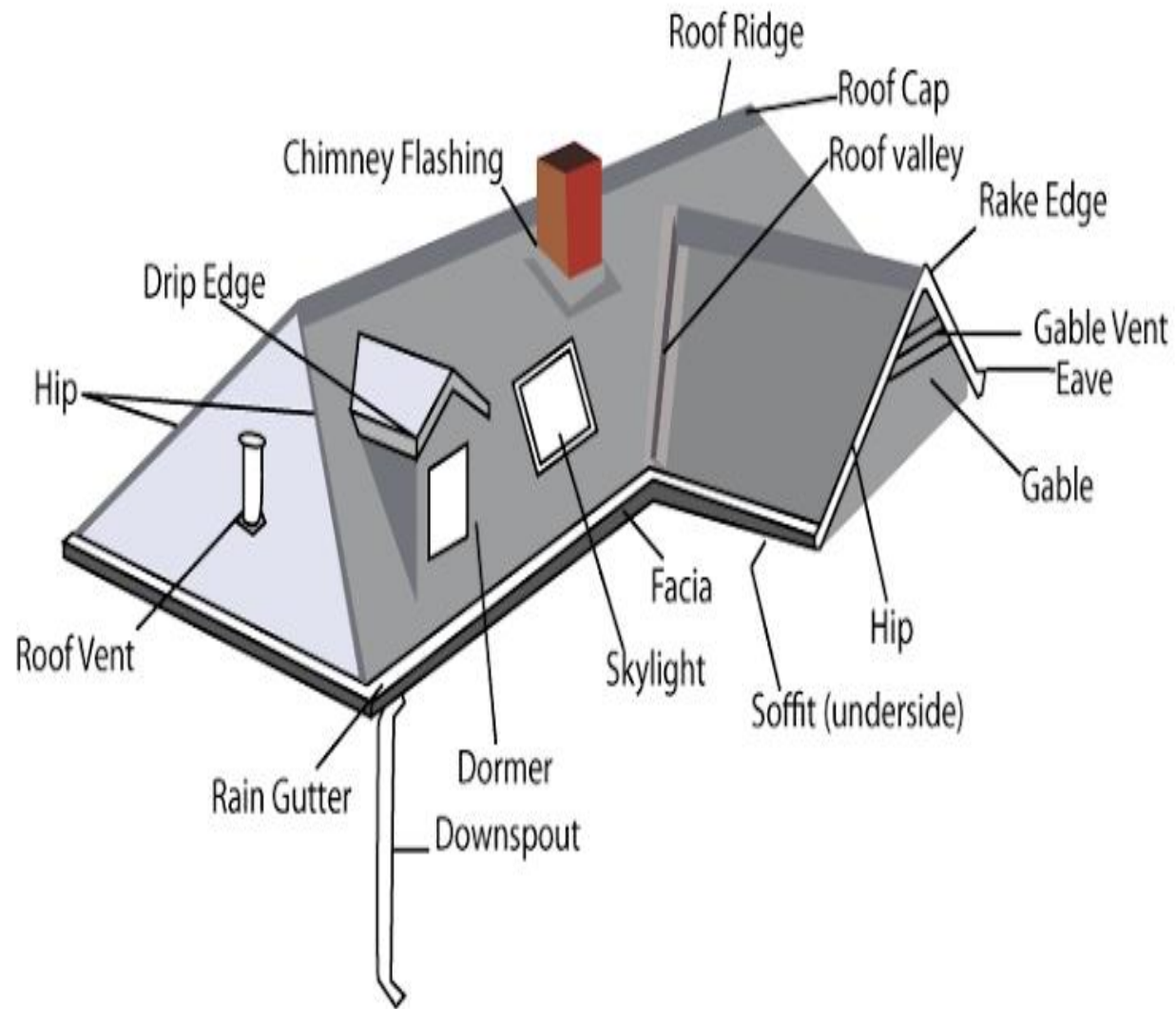
GLOSSARY OF TERMS:-

1. **Span:-** Span of roof is the clear distance between the two supports on which roof is positioned by some other elements.
2. **Ridge:-** The apex of the angle which is developed at top by the inclined surfaces at the top of slope.
3. **Rise:-** The vertical distance or height of top of ridge from wall plate is called as rise.
4. **Wall plates:-** Wall plates are provided at top of wall or supports. And these are generally made of wood and are used to fix the common rafters.
5. **Pitch:-** Pitch is nothing but slope of roof with the horizontal plane and is calculated as the ratio of rise to span.
6. **Eaves:-** The bottom edge of sloped roof surface is called as eaves from which rain water is drops down during raining.
7. **Hip:-** Hip is a place where two sloping surfaces meet, where exterior angle is more than 180°
8. **Hipped end:-** At the end of a roof sloped triangular surface is formed which is called as hipped end.
9. **Valley:-** It is also a place where two sloping surfaces intersects but the exterior angle is less than 180° .
10. **Verge:-** Verge is the edge of gable roof which runs between ridge and eaves.

- 11. Ridge board:-** Ridge board is a wooden member which is provided long the ridge or apex of the roof. Common rafters are supported by this ridge board. This is also called as ridge beam or ridge piece.
- 12. Common Rafters:-** Common rafters are wooden members fixed to the ridge board perpendicularly. They run from ridge to the eaves. These are fixed to the purlins at intermediate points. Batten or boarding's are supported by this rafter. In general, the spacing between rafters is 30 to 45 cm.
- 13. Purlins:-** Purlins are wooden or steel members supported by truss or wall. If the span is large they are used to support the common rafters.
- 14. Hip rafters:-** These rafters are provided at the hip end. And they run diagonally from ridge to the corners of the wall.
- 15. Valley rafters:-** Valley rafters run diagonally from ridge to the eaves. They are provided in sloping positions to bear support valley gutters. The ends of purlins and jack rafters will receive by the valley rafters.
- 16. Jack rafters:-** The rafters run from hip to the valley are called as jack rafters and usually they are short in length.
- 17. Eaves board:-** The ends of lower most roof covering materials are rests on eaves board. It is made of wood and usually 25mm x 25mm thickness and width. It is placed at the feet of common rafters.
- 18. Barge board:-** To hold the verge formed by the common rafters a wooden board is used which is called as barge board.

- 19. Post plate:-** Post plate is similar to wall plate. Post plates are parallel to the face of the wall and run continuous. Post plates provide support for the rafters.
- 20. Battens:-** Battens are usually made of wood and they are nailed to the rafters to give supports for the roof covering material.
- 21. Template:-** Template is a masonry block made of concrete or stone which is placed under the truss to provide larger load area of the wall.
- 22. Boarding's:-** Boarding's are similar to battens and these are also used to give support for the roof covering material by nailing them to the rafters.
- 23. Truss:-** Truss is frame which consists of triangles and designed to support the roof tops.
- 24. Cleats:-** To support the purlins, short sections of steel or wood are fixed to the rafters and these sections are called as Cleats.





TYPES OF ROOFS:-

Gable roof

The gable roof is a very popular type of roof: easy to build, sheds water well, facilitates ventilation and can be applied to most house designs.

Hip

Hip roof is slightly more difficult to build and usually has 4 sides. It's a popular choice but does not provide for ventilation. They do perform better in high wind areas.

Dutch

Dutch roof is basically a hip roof with a small gable at either end. The result is easier access to the lower portion of the roof with the added benefits of natural light and extra space.

Mansard roof

It is a French design and is more difficult to build than the hip or gable roof. It actually features two slopes within one on each side. The bottom part of the roof slope is steeper so that the pitch of the roof barely starts. This allows more room on the inside and in most cases creates an extra space.

Flat roof

Most flat roofs are not really 100% flat, they are low-sloped roofs that appear flat, but have a little bit of a slope to allow for the run-off water.

Shed roof

Shed roof is similar to a flat roof but has more pitch, it is frequently used for additions or with other roof styles.

Butterfly roof

This is a very modern design that is aesthetically unique. It provides plenty of light and ventilation but drainage is a problem.

Gambrel roof

It is also called barn roof because it has been used extensively on barns. It provides additional headroom in the attic.

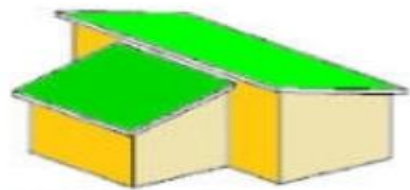
Dormer roof

A dormer is more an addition to an existent roof. It is a window and a roof (gabled, hipped, flat, among others) protruding from the existing slope of the roof. A functional dormer creates usable space out of the roof, adding natural light and headroom.

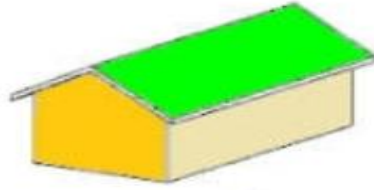
M Shaped

A M-shaped roof is basically a double gable roof featuring two sloped sides that meet in the middle with corresponding slopes on each side.

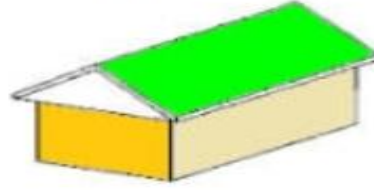
Roof Types



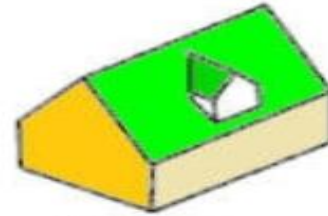
Skillion and Lean-to



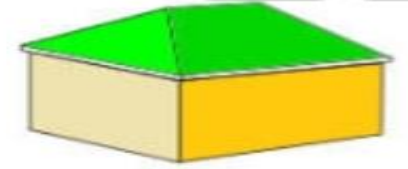
Open Gable



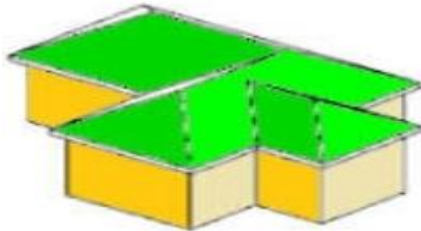
Box Gable



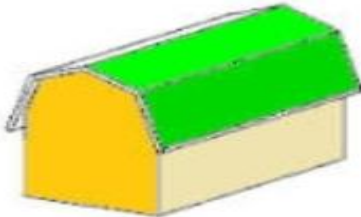
Dormer



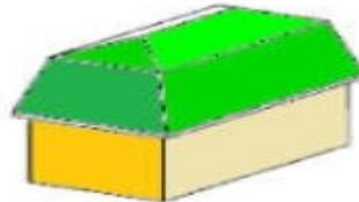
Hip



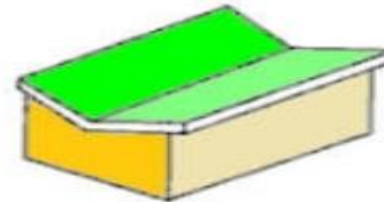
Hip and Valley



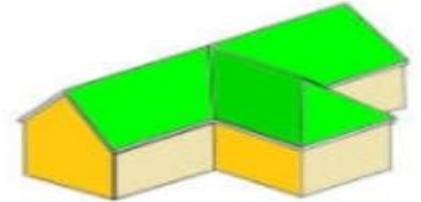
Gambrel



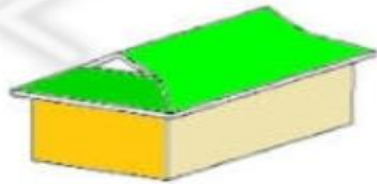
Mansard



Butterfly



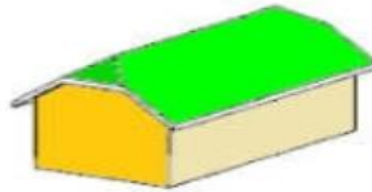
Intersecting /
Overlaid Hip



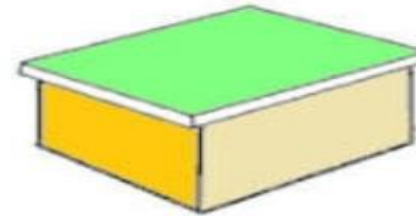
Dutch Gable



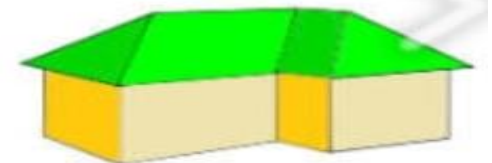
Hexagonal Gazebo



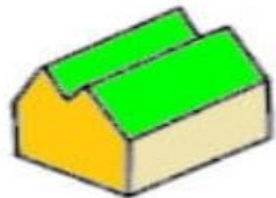
Jerkinhead



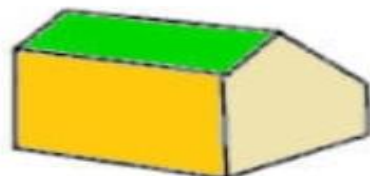
Flat



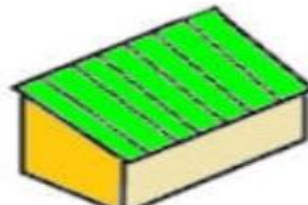
Cross Hipped



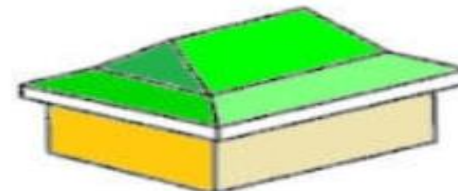
M shaped



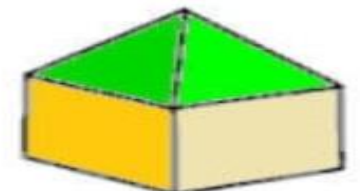
Saltbox



Shed

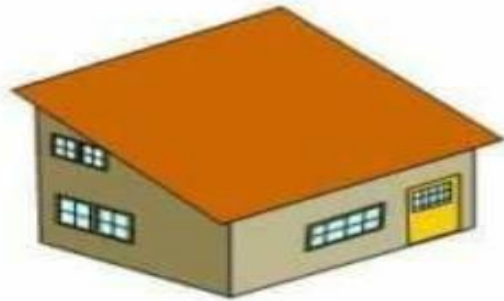


Combination

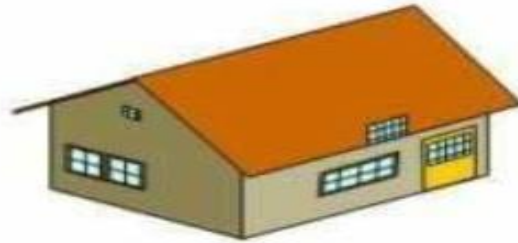


Pyramid Hip

Construction & Style



Shed



Gable



Mansard



Gambrel



Flat



Butterfly



Hip



Combination roof

Concept and function of *flat, pitched, hipped* and *Sloped roofs*

FLAT ROOF:-

- A roof which is nearly flat is known as flat roof. It should be noted that no roof can be laid perfectly level.
- The roof must slope in one direction or the other to cause rain water to flow off rapidly and easily. The construction of flat roof is same as that of floors except that the top surface is made slightly sloping in case of flat roofs.

ADVANTAGES OF FLAT ROOFS

The roof can be used as terrace for playing, gardening, sleeping and for celebrating functions.

- Construction and maintenance is easier.
- They can be easily made fireproof in comparison to pitched roof.
- They avoid the enclosure of the triangular space. Due to this, the architectural appearance of the building is very much improved.
- Flat roofs have better insulating properties.

DISADVANTAGES OF FLAT ROOF

- They are vulnerable to heavy temperature variations, specially in tropics, due to which cracks are developed on the surface. These cracks may lead to water penetration later, if not repaired in time.
- It is difficult to locate and rectify leak in flat roof.
- The speed of flat roof construction is much slower than the pitched roof.
- The initial cost of flat roof is more than pitched roof. The flat roofs exposes the entire building to the weather agencies, while the projecting elements of pitched roofs provide some protection to the building.

TYPES OF PITCHED ROOF

1. Single Roofs:

- Lean-to-Roof Couple Roof
- Couple-close Roof
- Collar beam Roof or Collar tie Roof

2. Double or Purlin Roof

3. Framed or Trussed Roof

- King Post Roof Truss
- Queen Post Roof Truss
- Combination of king-post & queen-post truss
- Mansard roof Truss

- SINGLE ROOFS

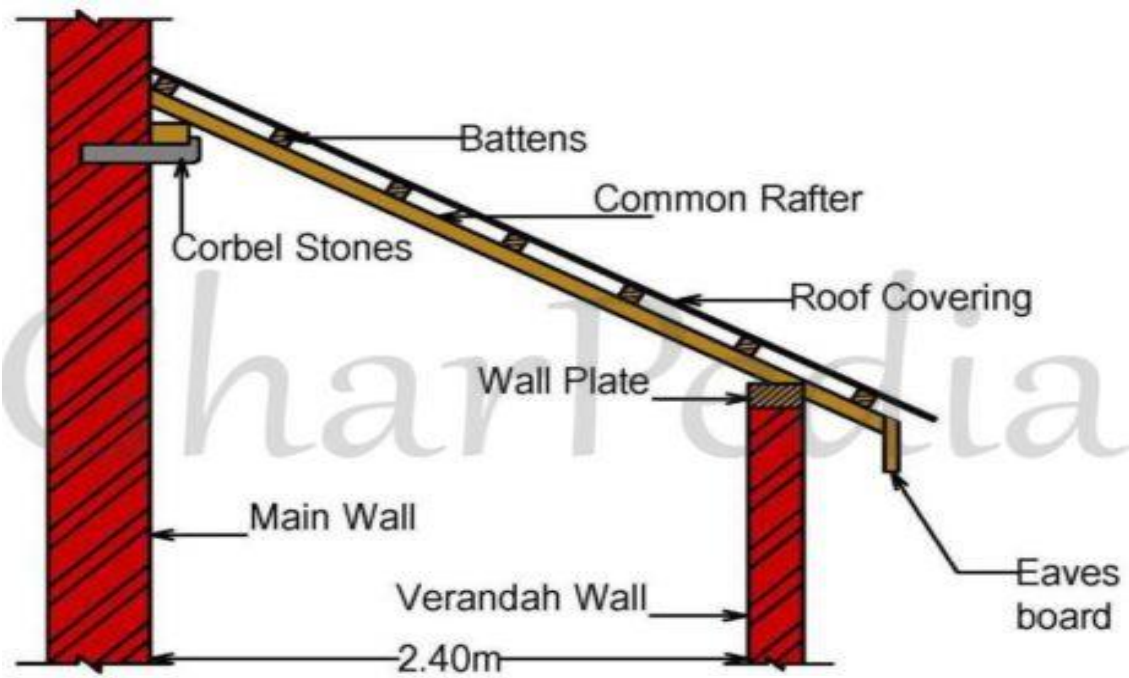
In this type of roofs common rafters are provided to each slope without any intermediate support. Such roof is used only when the span is limited to 5m.

It is of following types:

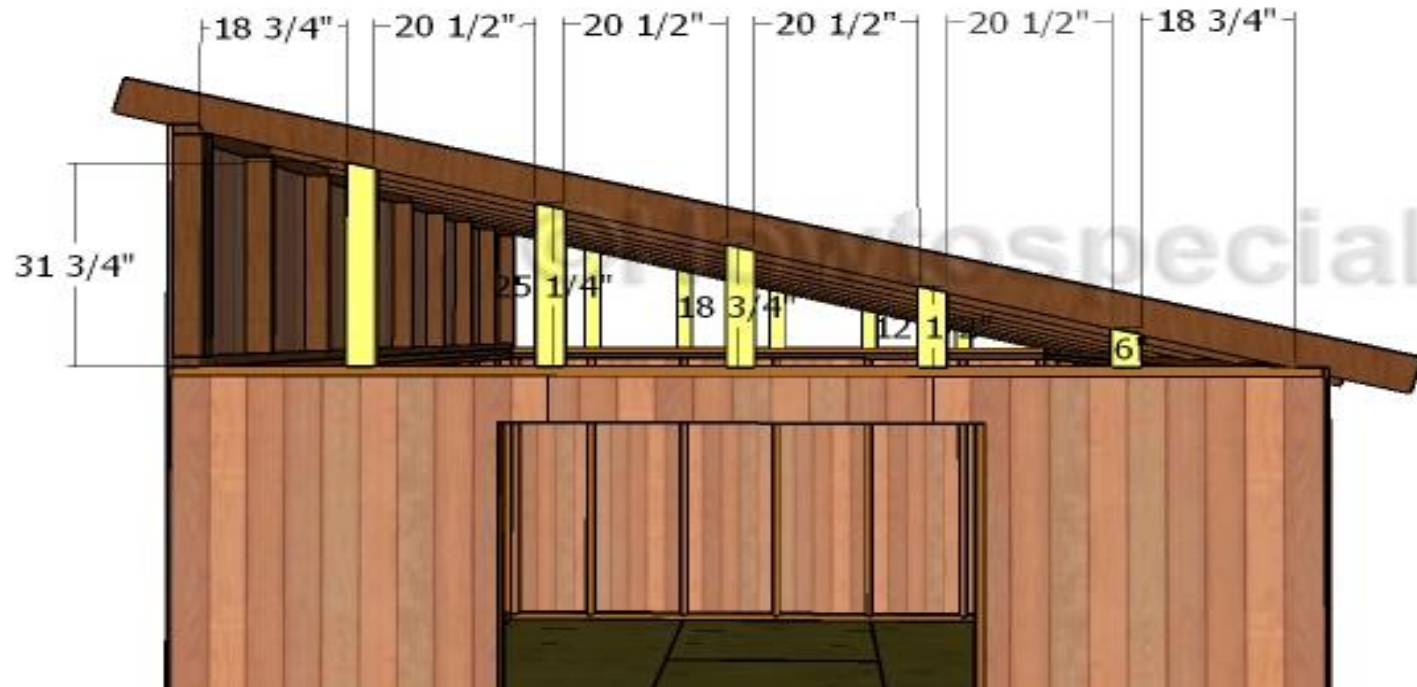
1. Lean-to-Roof
2. Couple Roof
3. Couple-close Roof
4. Collar beam Roof or Collar tie Roof

1. LEAN-TO-ROOF

- It is the simplest form of a pitched roof and it is known as pent roof or Aisle roof.
- In this type of roof, one wall is carried up sufficiently higher than the other to give necessary slope to the roof.
- A lean-to roof is generally used for sheds, outhouses attached to main buildings verandah etc. This is suitable for a maximum span of 2.4m..



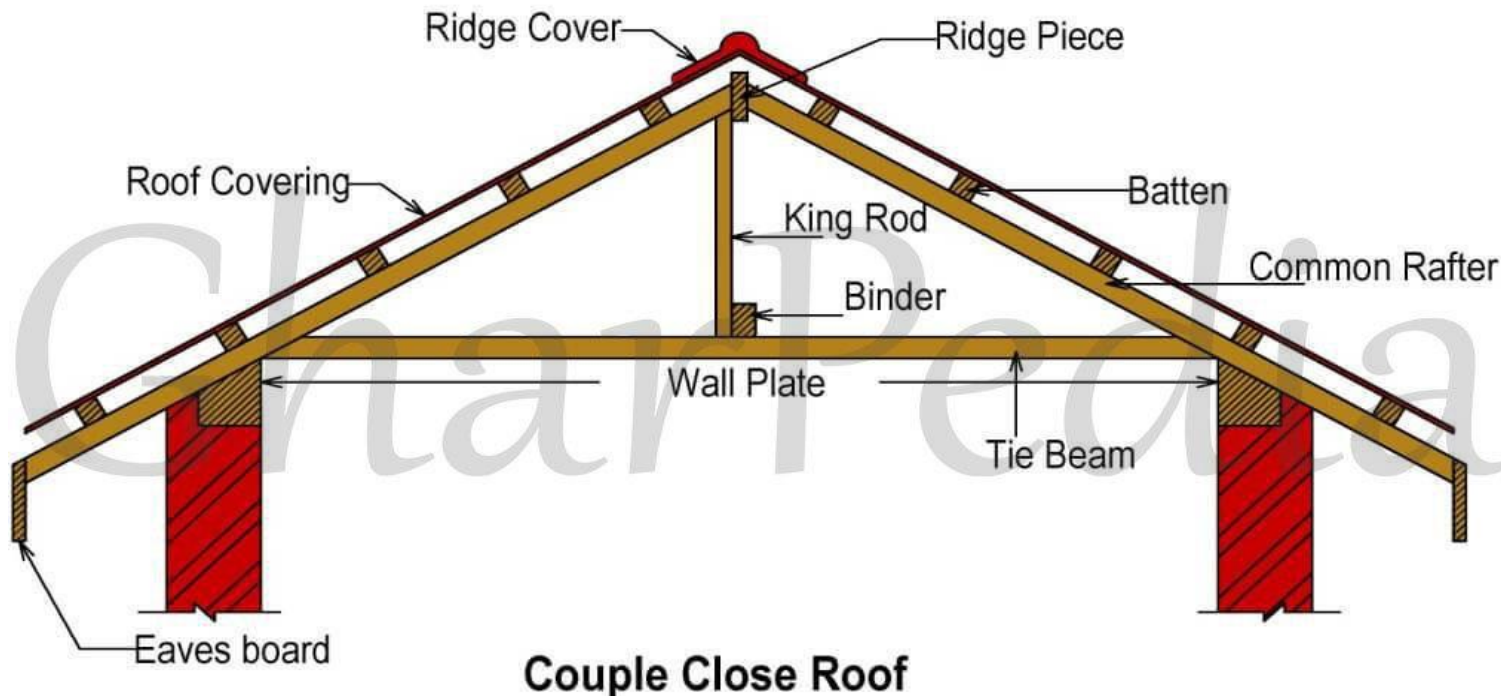
Lean to Roof



2. COUPLE ROOF

This type of roof is formed by couple or pair of rafters which slope to both the sides of the ridge of the roof.

In this type of roof the common rafters slope upwards from the opposite walls and they meet on a ridge piece in the middle. A couple roof is suitable for spans up to about 3.6m.

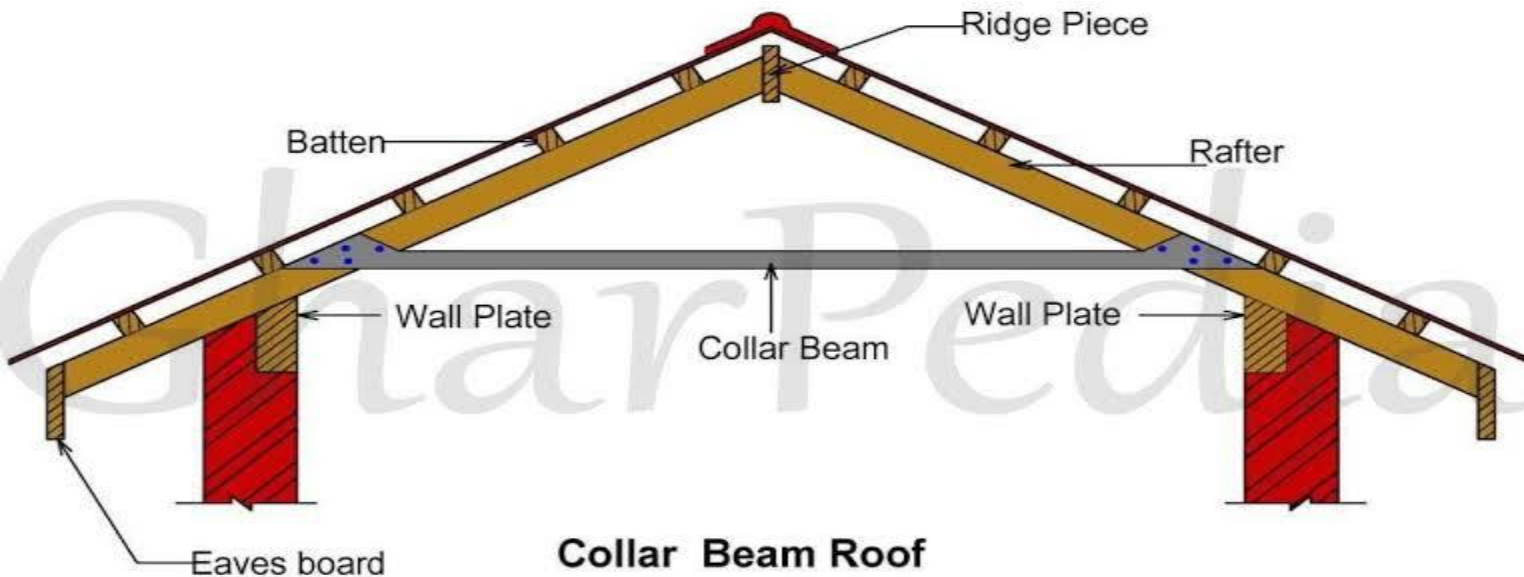


COUPLE CLOSE ROOF

- This roof is just similar to couple roof except that the ends of the couple of the common rafters is connected by horizontal member, called tie beam.
- The tie beam prevents the tendency of rafters to spread out and thus danger of overturning of the walls is avoided.
- The tie beam may be a wooden member or a steel rod.
- This roof can be adopted economically up to the span of 4.2m.

3. COLLAR BEAM ROOF

- When the span increases or when the load is more the rafters of the couple close roof have the tendency to bend. This is avoided by raising the tie beam and fixing it at one-third to one-half of the vertical height from the wall plate to the ridge.
- This raised beam is known as collar beam. This beam roof is adopted to economise the space and to increase the height of a room. This roof can be adopted up to a maximum span of 4.8m.



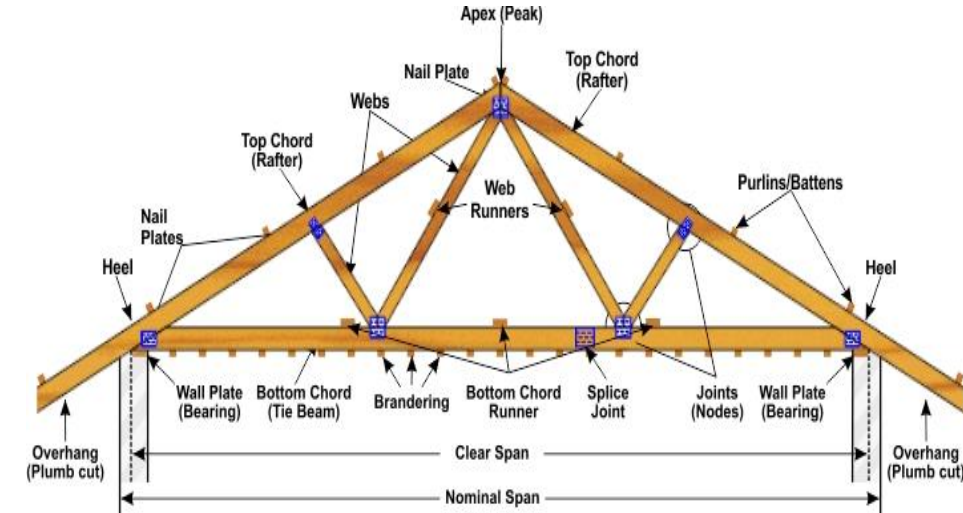
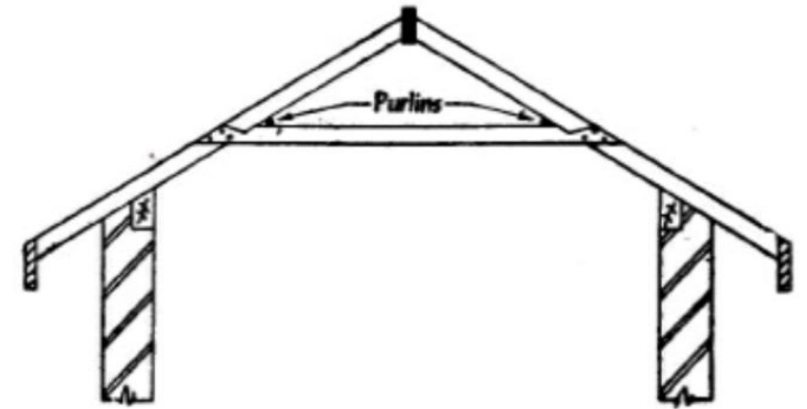
DOUBLE OR PURLIN ROOFS

- When the span exceeds 2.4m, the necessary size for the rafters becomes uneconomical. Hence in order to reduce the size of rafters, intermediate supports called purlins are introduced under the rafters. This roof can be adopted economically up to 4.8m.

FRAMED OR TRUSSED ROOF

- When the span exceeds 5 m and when there are no inside supporting walls or partitions for purlins, framed structure known as trusses are on the roof, position of cross walls, span and material of the truss.
- The spacing is 3m for wooden trusses. Trusses carry the ridge piece and purlins on which the common rafters rest.

DOUBLE OR PURLIN ROOFS

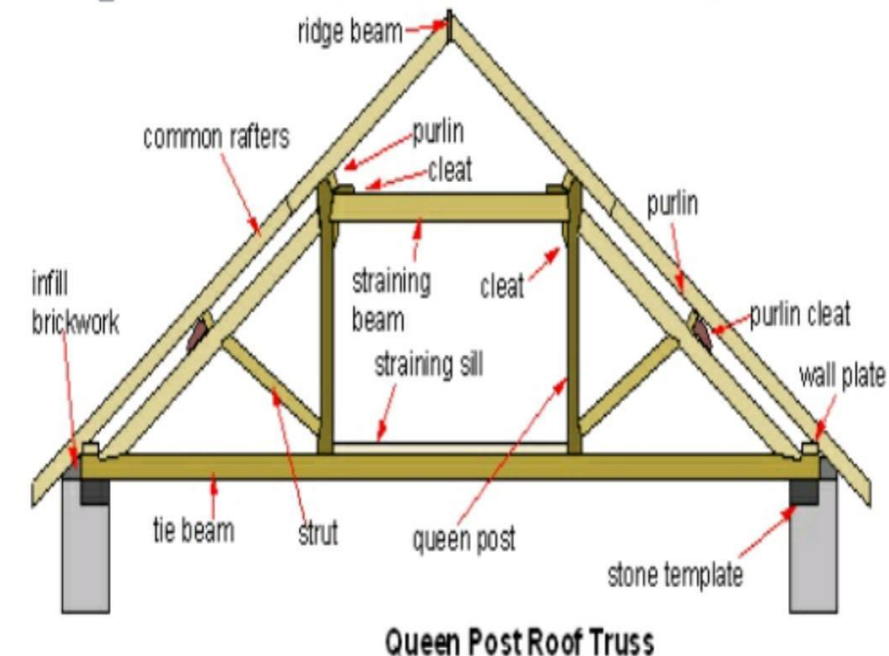
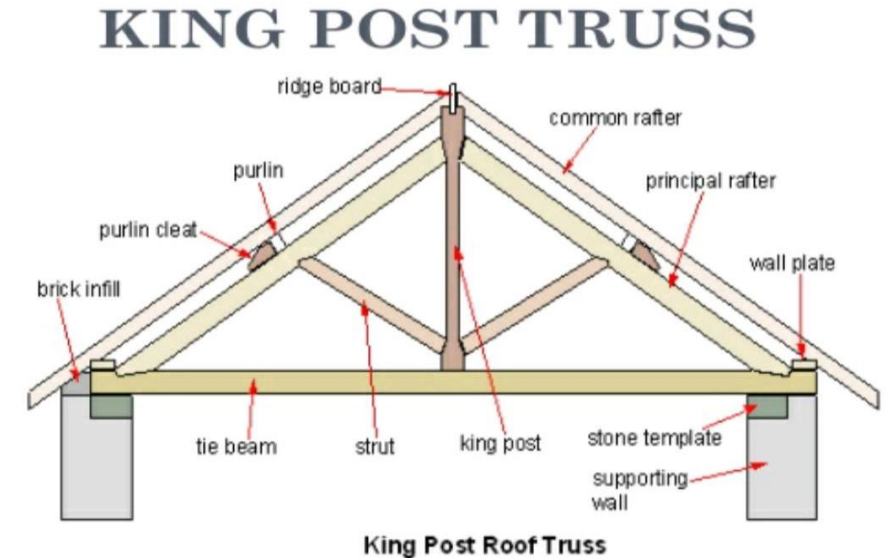


KING POST TRUSS

- In this type of truss, the central post known as king-post forms support for the tie beam.
- The inclined members, known as struts, prevents the principal rafters from bending in the middle.
- A king-post truss suitable for roofs of span varying from 5 to 8 m.

QUEEN POST TRUSS

- This truss is differ from a king-post truss in having two vertical members known as queen posts.
- The upper ends of the queen posts are kept in position by means of a horizontal member known as straining beam.
- Additional purlins are supported on the queen posts. A queen post truss is suitable for roof spans varying 8 to 12 m.



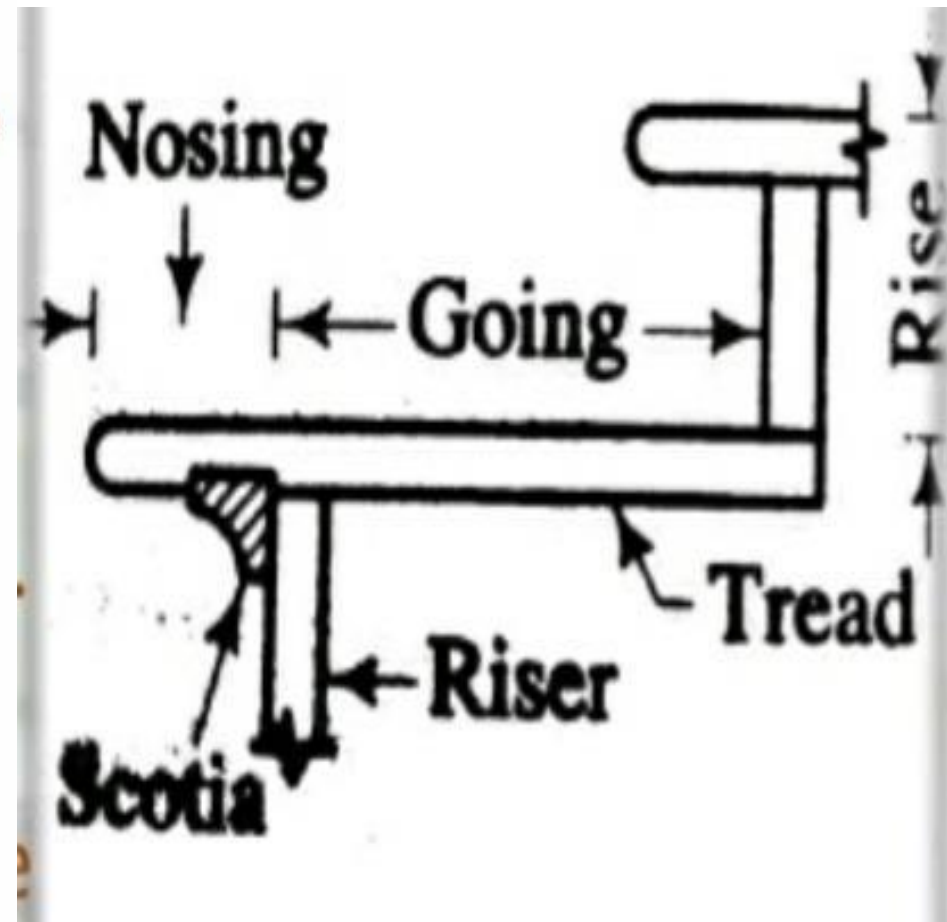
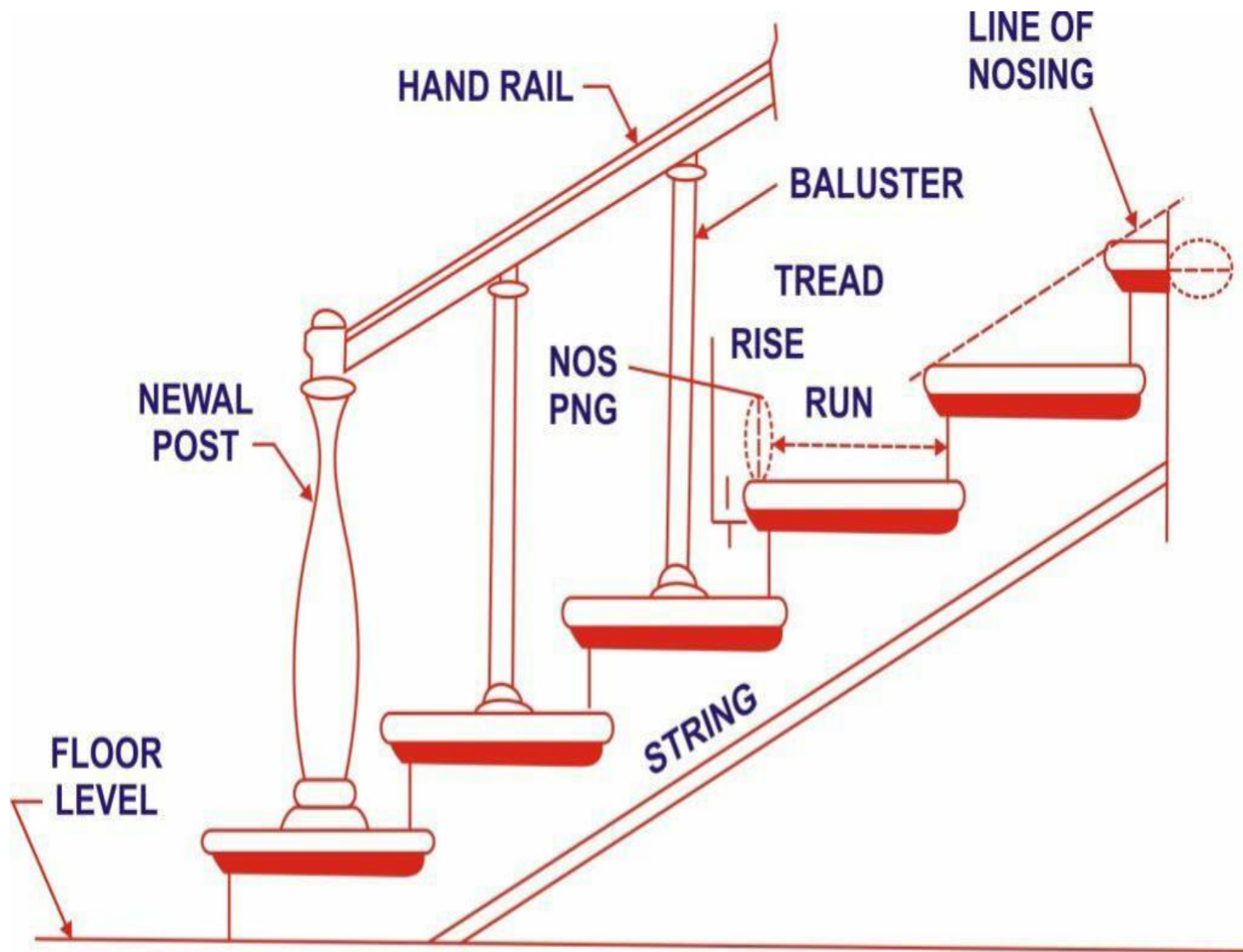


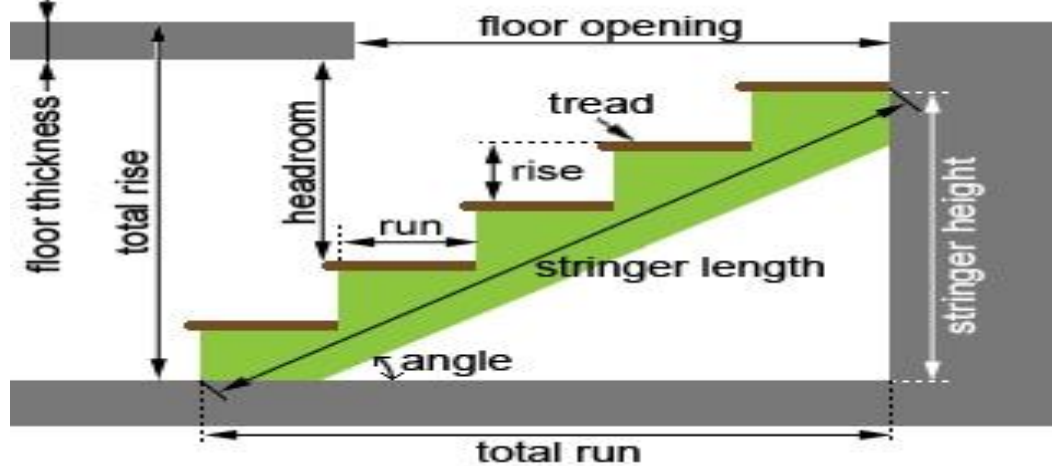
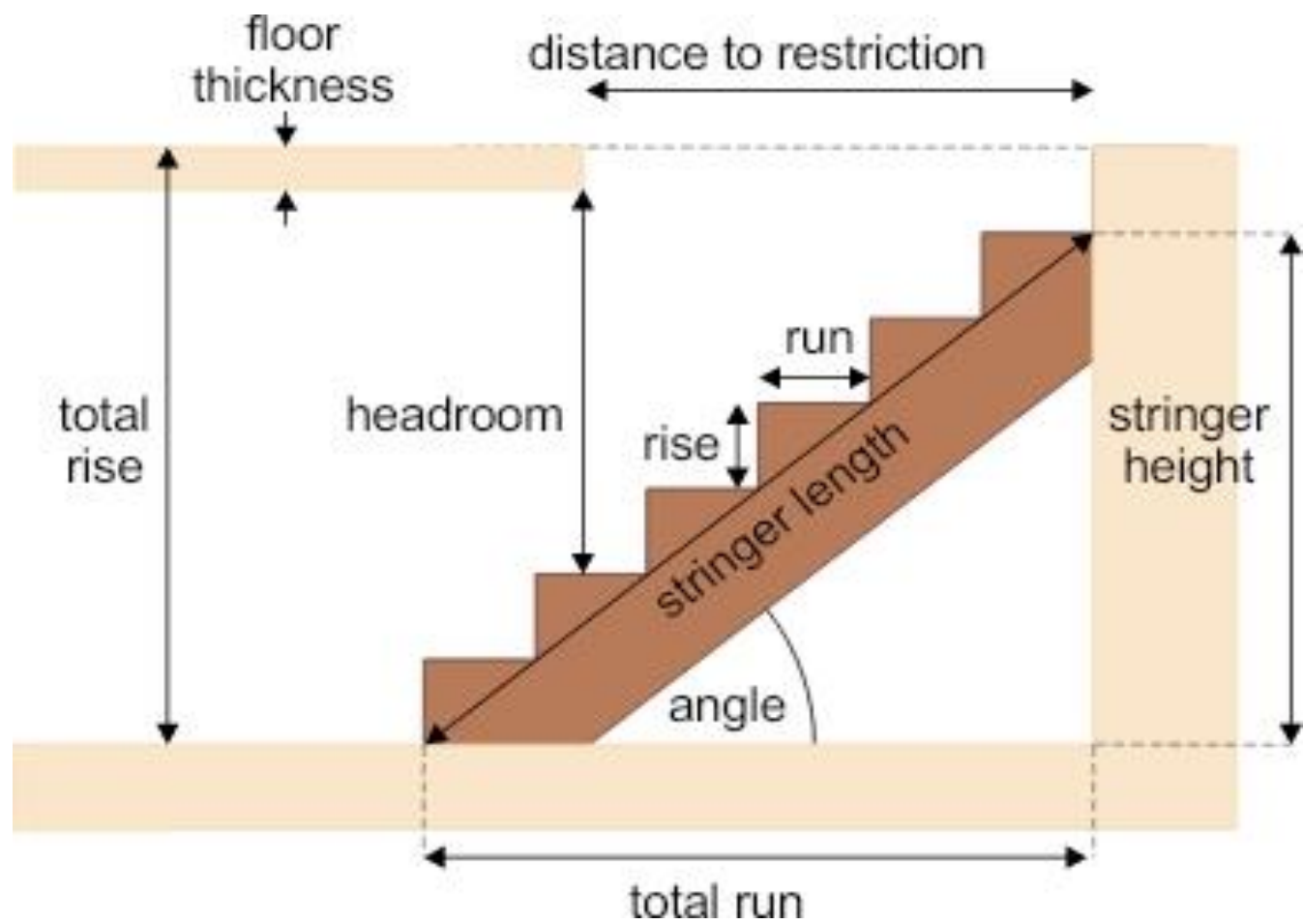
- 5.3 Stairs: Glossary of terms; Stair case, winder, landing, stringer, newel, baluster, rise, tread, width of stair case, hand rail, nosing, head room, mumty room.

Technical Terms used in Staircases :-

1. **Stairs.** Stairs are steps arranged in series for the purpose of an access from one floor to the other.
2. **Stair-case.** The room or apartment in which stairs are enclosed, is called stair-case.
3. **Rise.** It is the vertical distance between the two consecutive steps. The vertical portion of the step is called
4. **Tread.** The horizontal portion of the step is called tread. The horizontal distance between the two consecutive risers is called *Go, Going* or *Run*.
5. **Nosing.** It is the front edge of the tread which projects beyond the riser.
6. **Fliers.** The rectangular steps of uniform shape and size are called Fliers.
7. **Winders.** The triangular or wedge shaped steps, used for changing the direction are called winders.
8. **Flight.** It is a continuous series of steps in one direction,, separated by horizontal platforms or winders.
9. **Landing.** It is the horizontal platform provided at the top-of a flight. If the landing is of a rectangular shape, having a length equal to twice the width of the stairs, the landing is called *Half Space Landing*. If on the other hand, the stairs run at right angles to each other and are separated by a square landing, the landing is-called *Quarter Space Landing*.

9. **Scotia block.** It is a triangular wooden block used below the nosing to give it additional strength.
10. **Strings or stringers.** These are inclined members which support the steps.
11. **Headroom:-** It is the space that lies between the head and sill of a doorway or between the ceiling and floor, allowing passage of a person standing upright.
- **Headroom** is also the height above the nosing of a tread to the ceiling above it.
 - The minimum head room over a stair must be 2.1m
9. **Railing.** This is a moulded block of wood or some other material, provided to afford assistance and safeguard to persons while going on the stairs. The height of a railing should be nearly-75 cm above the line of nosing.
10. **Balusters.** These are short vertical members which support the hand-railing.
11. **Balustrade or Banister.** The composite member consisting of a hand rail, balusters, newel posts is called balustrade.
12. **Newel posts.** These are principal balusters used at the 'top and bottom of a flight.





standard mount

flush mount

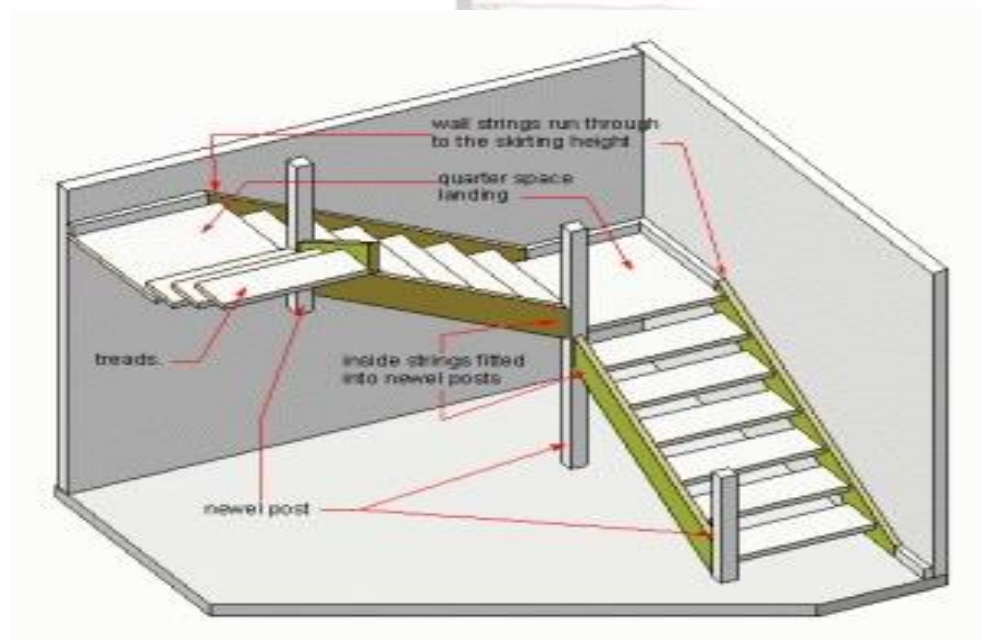
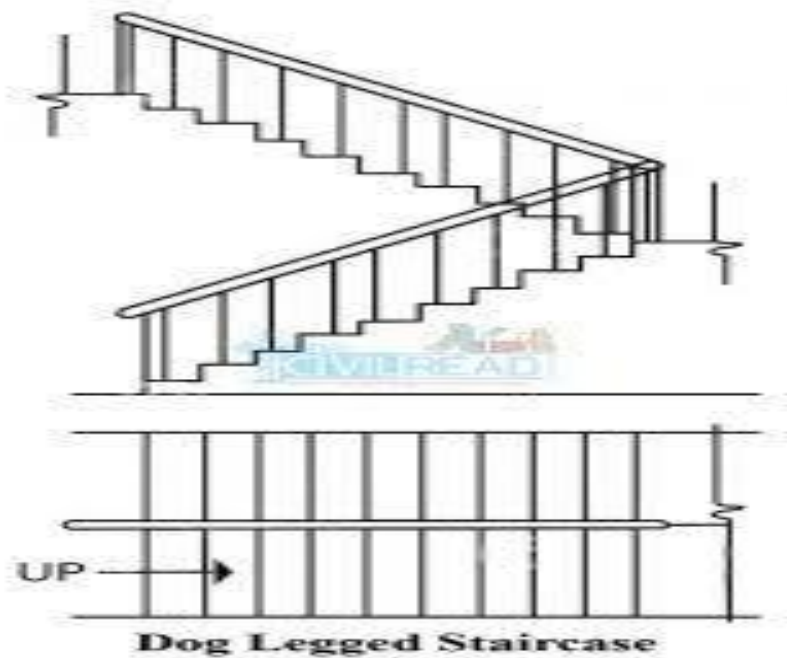
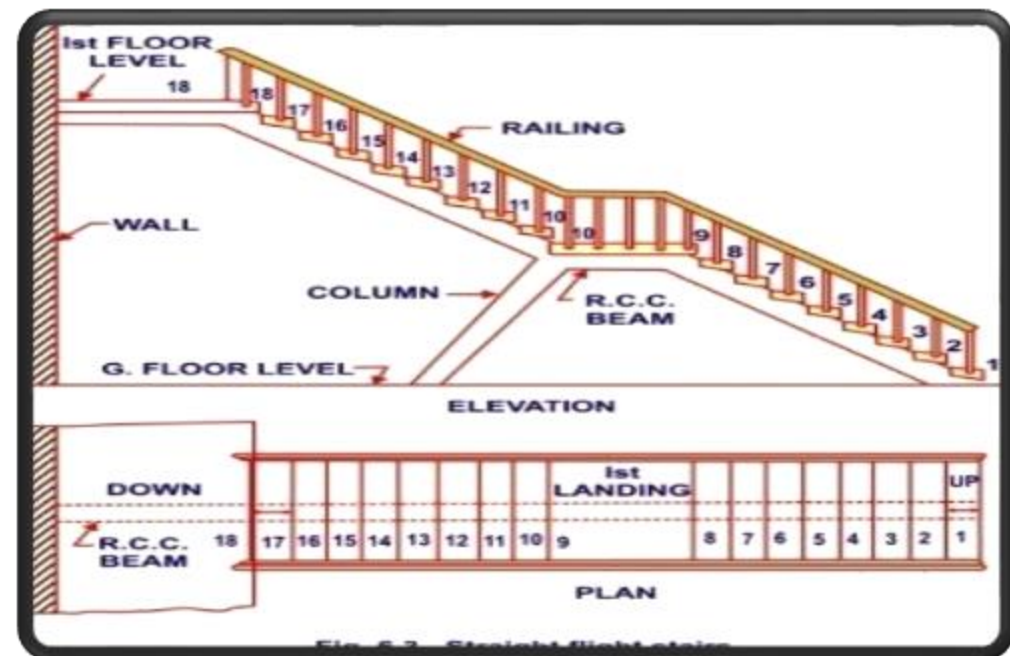
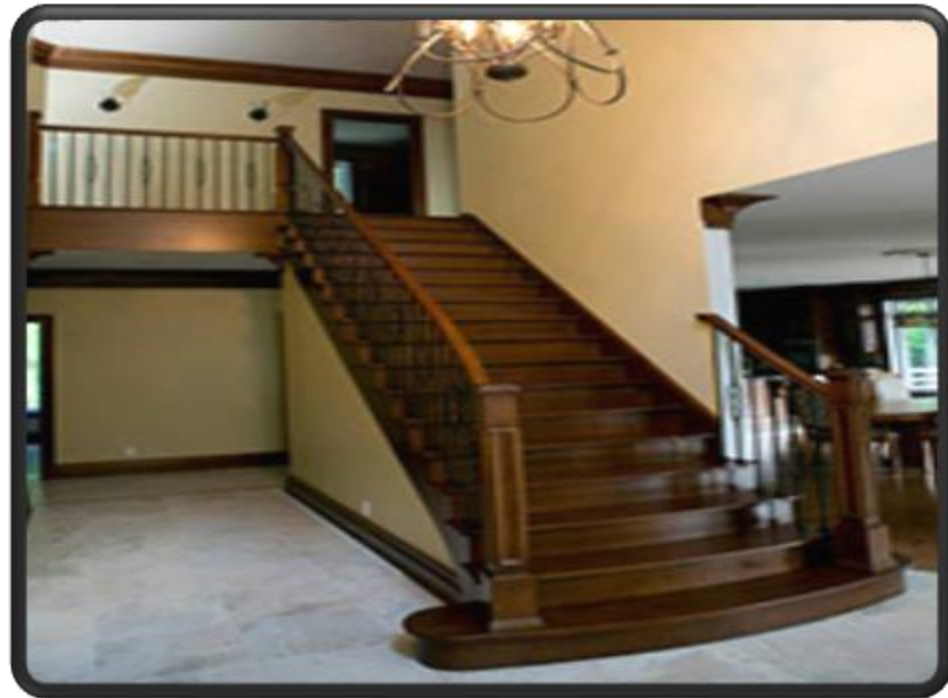


- 17. Mumty Room:-** A small **room** with only one purpose; to provide a roof over **staircase**. You don't want your **stairs** to be out in open on the roof. It has to be covered with walls and roof to keep rain and dust from going down the **stairs** to the **rooms**.
- 18. Width of Staircase:-** Depending on the use and local regulations, a minimum **width** of 80 cm is recommended for **stairs** in single-family homes, and greater than 1.00 meters in public buildings, taking into consideration the tentative number of people who will use it.

- Various types of stair case – straight flight, dog legged, open well, quarter turn, half turn (newel and geometrical stairs), bifurcated stair, spiral stair, cantilever stair, tread riser stair.

Straight staircases

- The straight staircase generally has one straight flight of stairs, or sometimes two separated by a landing part way up. The straight staircase enables the user to continue going in the same direction between two consecutive floors.
- This type of stairway is economical and easy to design with all types of possible stringers. However, it uses more floor space.
- Intermediate landings can be incorporated into a straight staircase, making it safer with a resting place partway up.
- With the exception of a landing between two flights of stairs, all the treads are rectangular and of the same dimensions.



Dog legged stairs.

- It is a very common and popular type of stairs and is used in public as well as residential buildings.
- It consists of two flights running in opposite directions, separated by a half space landing or a quarter space landing and a set of winders.
- The dog-legged stair is so called because the bent of the stairs is similar to the dog's leg.
- When the space available is equal to twice the width of the stairs, dog legged stair is used.

Open newel or Open well stairs.

- It is similar to the dog legged, stair except that in this case the two flights are separated by an open well.
- The open newel stair is a convenient type of stair and is generally used in public buildings. The width of the open well depends upon the space available but it varies from 60 cm to 120 cm.
- The two flights are either separated by a half space landing or two quarter space landings with a set of steps. The open well between the two flights can be used for fixing a 'Lift'.

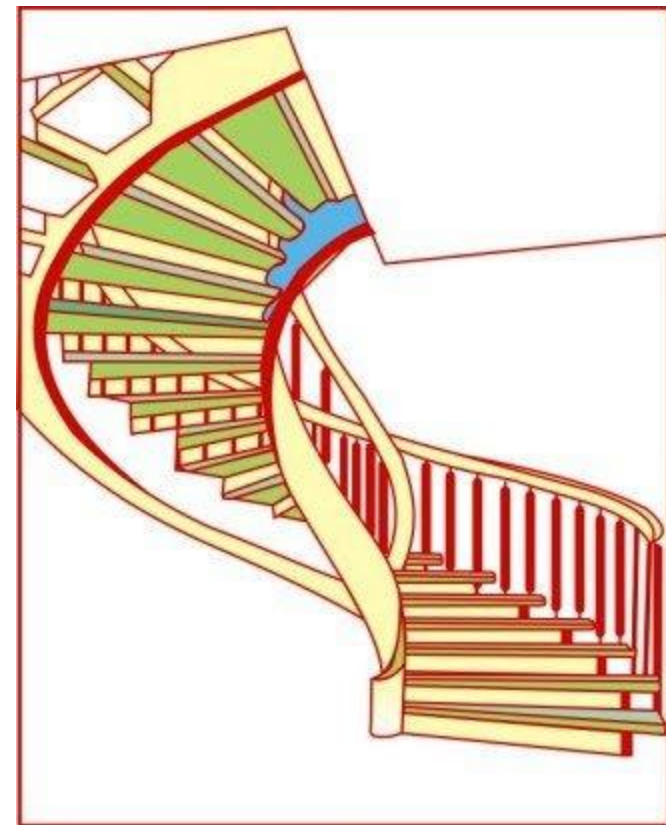
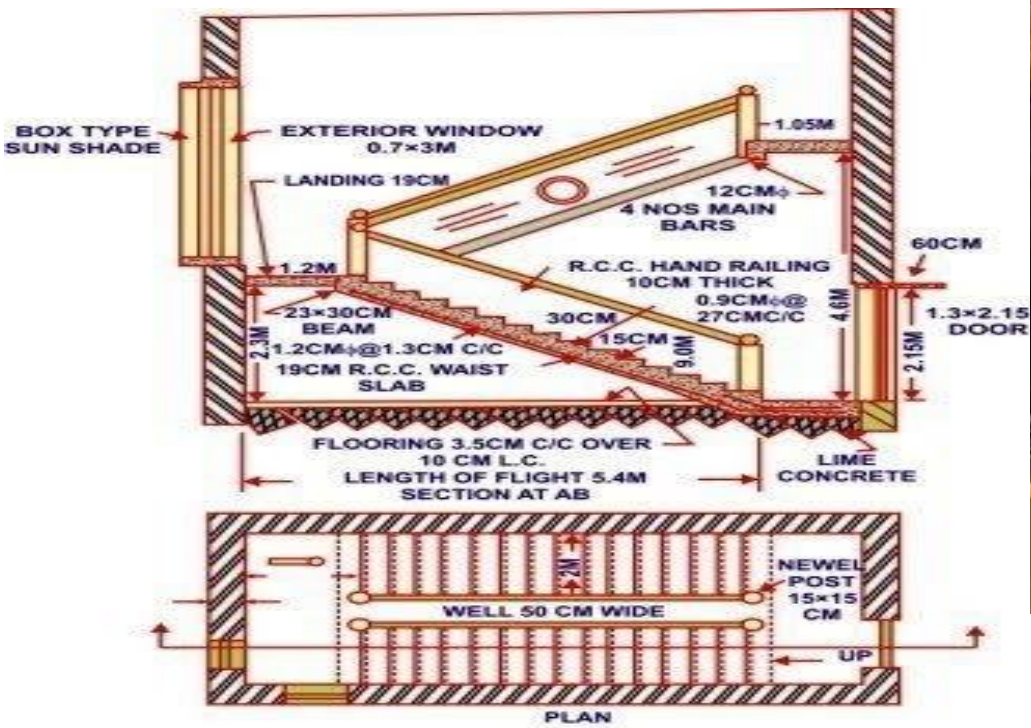


Fig. 6.9. Isometric view of geometrical stairs.

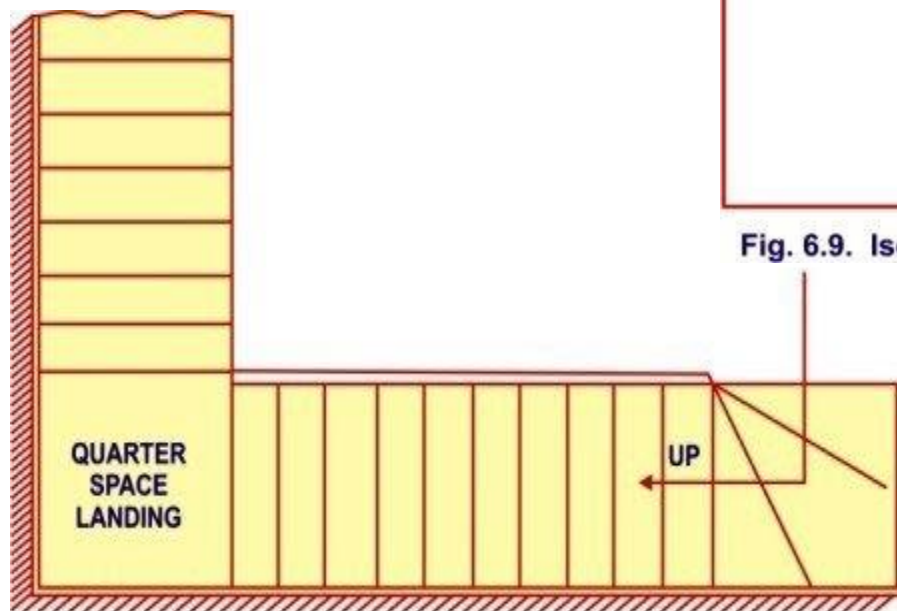
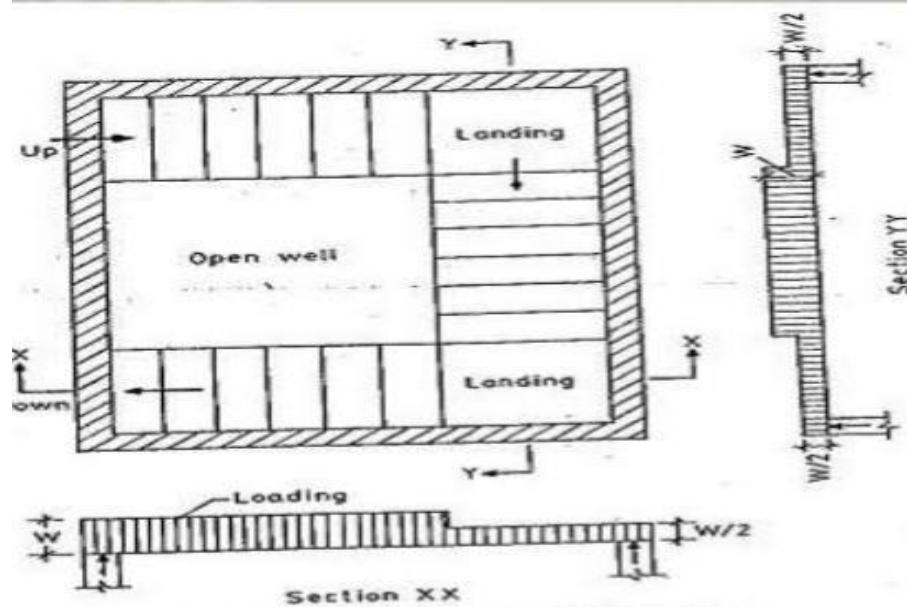


Fig. 6.6. Quarter turn stairs.

Quarter turn stairs.

- In this type of stair, the two flights run at right angles to each other and are separated by a quarter space larding.
- The stairs are generally provided when wall support is on one side only, or when in a huge apartment such as an entrance hall, stairs are to be provided.

Geometrical stairs.

- The geometrical stairs are generally used in high class residential buildings. The stair is in the form of some curve, having all the steps as winders, radiating from the-centre of curvature of the curve.
- The hand rail of a geometrical stair, continues without interruption and without any angular turn-Considerable skill is required for the designing and construction of a geometrical stair.
- The minimum width of this stair has been, fixed at 1.75 m.

Bifurcated stairs.

- These stairs are commonly used in public buildings. In this type of stairs, the bottom flight is **wider** and is bifurcated into two narrower flights at the landing.
- The bifurcated stairs may be of two types, viz. *Quarter turn* and *half turn*.
- In the quarter turn type, the upper the lower flights run at right angle whereas in the half turn bifurcated stairs, the sets of flights go in opposite directions as in a quarter turn stair and dog-legged stair respectively.

Spiral stairs.

- These stairs are generally constructed either of cast iron or R.C.C. The steps which are all winders, radiate from a central vertical shaft and are attached to it.
- The steps are generally pre-cast and are fitted to the central pillar.
- These stairs are used on the back-side of a building for emergency use as well as in those places where the space is limited.

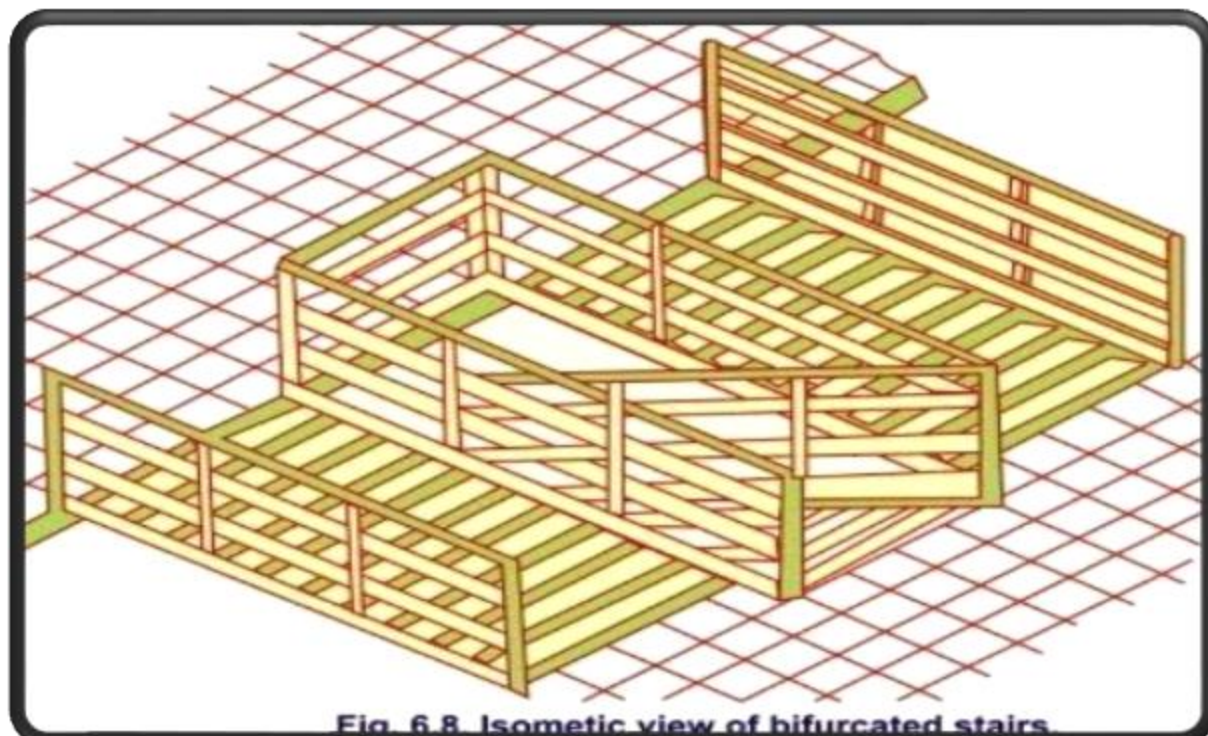


Fig. 6.8. Isometric view of bifurcated stairs

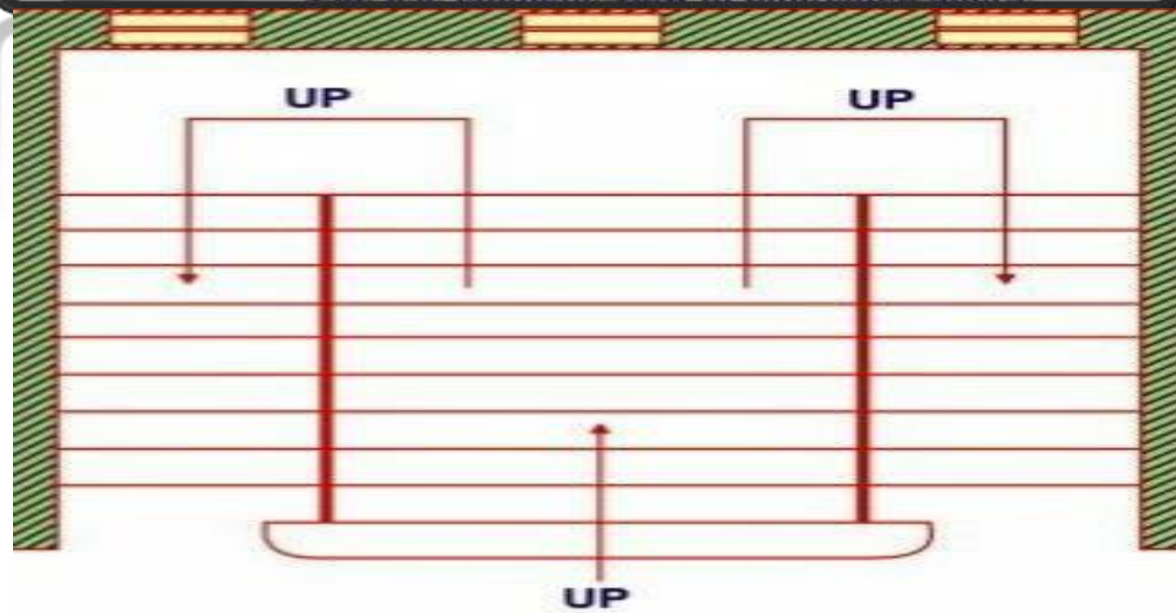
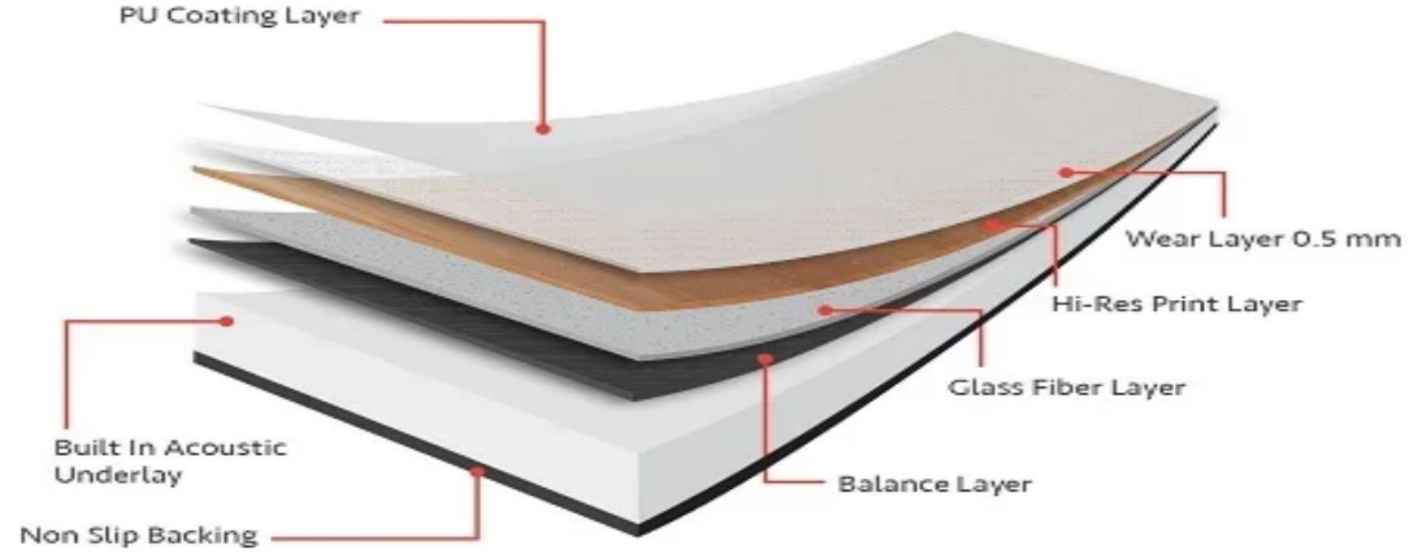
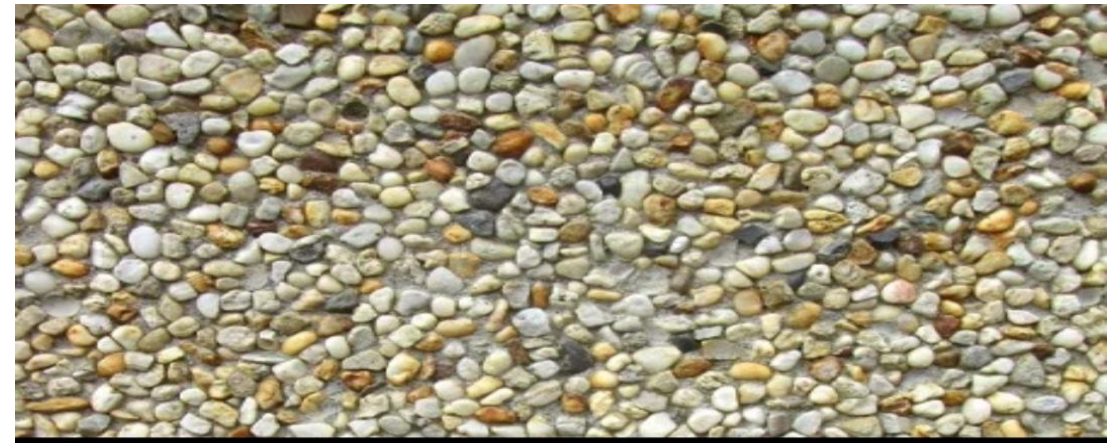
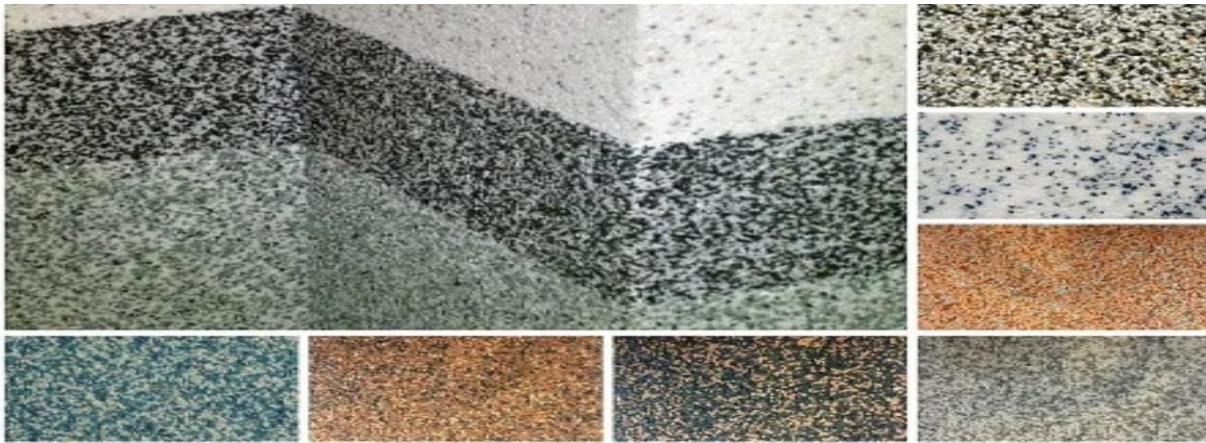


Fig. 6.10. Spiral stairs.



Chapter 6

PROTECTIVE, DECORATIVE FINISHES, DAMP AND TERMITE PROOFING



- Protective, Decorative Finishes, Damp and Termite Proofing

6.1 Plastering – purpose – Types of plastering, Types of plaster finishes – Grit finish, rough cast, smooth cast, sand faced, pebble dash, acoustic plastering and plain plaster etc.

6.2 Proportion of mortars used for different plasters, preparation of mortars, techniques of plastering and curing

6.3 Pointing – purpose –Types of pointing

6.4 Painting – objectives – method of painting new and old wall surfaces, wood surface and metal surfaces – powder coating and spray painting on metal surfaces.

6.5 White washing – Colour washing – Distempering – internal and external walls.

6.6 Damp and Termite proofing – Materials and Methods.

6.1 Plastering – purpose – Types of plastering, Types of plaster finishes – Grit finish, rough cast, smooth cast, sand faced, pebble dash, acoustic plastering and plain plaster etc.

PLASTERING & IT'S PURPOSE:-

- Plaster is a thin layer of mortar applied over the masonry surface and it acts as a damp-proof coat over the brick masonry work.
- Plastering also provides a finished surface over the masonry that is firm and smooth hence it enhances the appearance of the building.
- The primary objectives of plastering are to protect the surface from atmospheric influences, to cover the defective workmanship in masonry, to conceal porous materials, and to provide a suitable surface for painting.

TYPES OF PLASTERING FINISHES:-

- Grit finish
- rough cast
- smooth cast
- sand faced
- pebble dash
- acoustic plastering
- plain plaster

1. GRIT FINISH:-

This plaster is a textured plaster layers in panels with grooves as per pattern With different type of stone chipping 10 mm. nominal sue.

Min thickness is 30mm

COMPOSITION- (1 cement: 0.5coarse sand:2 stone chipping (10mm nominal size)Depend upon types stone chips.

PROPERTIES.

- High moisture Resistance
- High durability
- Good termite Resistant
- Good to protect from Environmental hazards



2. ***Rough Cast:-***

- 1:1:3 = Cement: Sand: Aggregate are used to prepare mortar for this type of finish. The coarse aggregate may vary from 3 mm to 12 mm in size.
- The mortar is thrown on the prepared plaster surface then by means of a large trowel. The surface is then roughly finished using a wooden float.
- This finish is water-proof, durable, and resistant to cracking and crazing. It is used for external rendering.



3. ***Smooth cast:-***

In this type of finish, the finishing coat is a smooth and levelled surface. The mortar used is made of cement and fine sand 1:3. Mortar is applied with the help of wooden float.



4. ***Sand Finish:-***

- Sand faced finish is applied in two coats. The first coat is applied in 1:4 cement sand mortar of 12 mm thickness.
- It is provided with zig-zag lines. After curing it for seven days, the second coat is applied in the thickness of 8 mm.
- The mortar for a second coat is prepared from the cement sand mix ratio 1:1. The sand of uniform size is used. A sponge is used in a second coat when it is wet.
- The surface of the final coat is finished by rubbing clean and washed sand of uniform size by means of wooden float. This results in the surface having sand grains of equal and uniform density.



5. *Pebble Dash plaster:-*

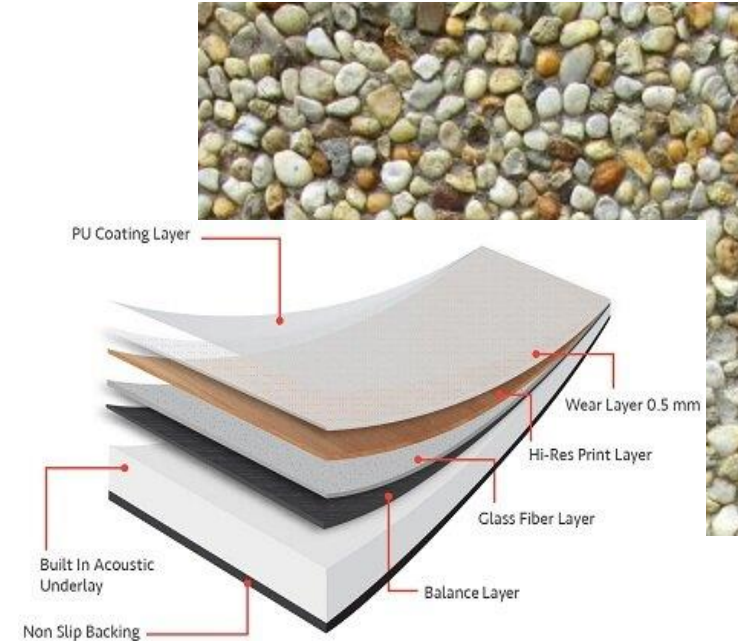
- In this finish, clean pebbles of size from 10 to 20 mm size are dashed against the final coat of plaster.
- The pebbles may be lightly pressed into the mortar with the help of wooden float. The final coat of plaster is having Cement: sand mix proportion of 1:3 and thickens 12 mm.

6. *Acoustic Plastering :-*

- The materials like gypsum mixtures are added in mortar for finishing coat such a coat undergoes a chemical reaction and produces gas bubbles and due to the bubbles tiny openings are formed in the coat and it appears like a honeycomb.
- These honeycomb minute openings absorb sound. Such plaster is useful in interior walls of halls auditorium etc.

7. *Plain plaster:-*

It is the normal plaster we usually applied on the surface of wall for smooth finish.



Proportion of Cement Mortar

The Proportion means the relative quantity of different components to be mixed to make good mortar, or simply the ratio between different materials.

Following are the proportions of cement mortar which is commonly recommended for different works:

01. Masonry Construction:

- For ordinary masonry work with brick/ stone as a structural unit. – **1:3 to 1:6**
- For reinforced brick work – **1:2 to 1:3.**
- For all work in moist situations – **1:3**
- For Architectural work – **1:6**
- For Load Bearing structures – **1:3 or 1:4**

02. Plaster Work:

- For External Plaster and Ceiling Plaster – 1:4
- Internal Plaster (If sand is not fine i.e. Fineness Modulus > 3) – 1:5
- For Internal Plaster (if fine sand is available) – 1:6

Flooring Work:

- Mortar ratio of 1:4 to 1:8 (cement: sand, water to be judgmental), for 5 to 7 times thickness of verified tiles, should be given as bed between RCC floor and tiles.

04. Pointing Work:

- For pointing work proportion of cement mortar should be 1:1 to 1:3

Mortar Mixing Procedure:-

- Mortar is mixed on-site in a mechanical mixer but can be mixed in smaller amounts by hand, using a hoe and a mixing tub or wheelbarrow.
- Use a dry bucket to measure out the materials.
- Pre-wet mortar containers before filling them with fresh mortar.
- Prepare a container with a flat, solid surface base and tall sides for mixing mortar, if mixing by hand.
- Add the masonry cement, lime, and sand in the appropriate amounts to your mixing container, then add water on top of the dry ingredients.
- Fold the mortar mix from the bottom into the water, when mixing by hand. Keep mixing until the water is mixed in. Then, add more water and keep mixing. Keep adding water until the mortar attains a smooth consistency.
- Stop mixing when the mortar is wet enough to slip easily off the shovel but holds its shape if you make a hollow in the mix. Mortar has attained the correct viscosity when you can make a few ledges in the mortar mix and ledges stand up.

- ***Procedure of Plastering Work***

- ◇ ***Preparation of Surface for Plastering***

1. Keep all the mortar joints of wall rough, so as to give a good bonding to hold plaster.
2. Roughen the entire wall to be plastered.
3. Clean all the joints and surfaces of the wall with a wire brush, there should be no oil or grease etc. left on wall surface.
4. If there exist any cavities or holes on the surface, then fill it in advance with appropriate material.
5. If the surface is smooth or the wall to be plastered is old one, then rake out the mortar joint to a depth of at least 12 mm to give a better bonding to the plaster.
6. Wash the mortar joints and entire wall to be plastered, and keep it wet for at least 6 hours before applying cement plaster.
7. If the projection on the wall surface is more than 12 mm, then knock it off, so as to obtain a uniform surface of wall. This will reduce the consumption of plaster.

♦ ***Groundwork for Plaster***

1. In order to get uniform thickness of plastering throughout the wall surface, first fix dots on the wall. A dot means patch of plaster of size 15 mm * 15 mm and having thickness of about 10 mm.
2. Dots are fixed on the wall first horizontally and then vertically at a distance of about 2 meters covering the entire wall surface.
3. Check the verticality of dots, one over the other, by means of plumbbob.
4. After fixing dots, the vertical strips of plaster, known as screeds, are formed in between the dots. These screeds serve as the gauges for maintaining even thickness of plastering being applied.

♦ ***Applying Under Coat or Base Coat***

1. In case of brick masonry the thickness of first coat plaster is in general 12 mm and in case of concrete masonry this thickness varies from 9 to 15 mm.
2. The ratio of cement and sand for first coat plaster varies from to 1:6.
3. Apply the first coat of plaster between the spaces formed by the screeds on the wall surface. This is done by means of trowel.
4. Level the surface by means of flat wooden floats and wooden straight edges.
5. After leveling, left the first coat to set but not to dry and then roughen it with a scratching tool to form a key to the second coat of plaster.

♦ ***Applying Finishing Coat***

1. The thickness of second coat or finishing coat may vary between 2 to 3 mm.
2. The ratio of cement and sand for second coat plaster varies from 1:4 to 1:6.3. Before applying the second coat, damp the first coat evenly.
3. Apply the finishing coat with wooden floats to a true even surface and using a steel trowel, give it a finishing touch.5. As far as possible, the finishing coat should be applied starting from top towards bottom and completed in one operation to eliminate joining marks.

◇ ***Curing of Plastering works***

1. After completion of the plastering work, it is kept wet by sprinkling water for at least 7 days in order to develop strength and hardness.
2. Use of gunny bags or other materials is used to keep the plastering works wet in external works.
3. Improper curing may lead to cracks formation or efflorescence in plaster work.

Care be taken after Completion of Plaster Work

- Cleaning of doors or frame and floor area is necessary at the completion of work.
- Curing should be started as soon as the plaster has hardened sufficiently and must be cured for at least 7 days.
- Curing shall commence, 24 hours after the plaster is laid.

6.3 Pointing – purpose –Types of pointing

- ***POINTING*** is the finishing of mortar joints in brick or stone masonry construction.

Purpose:-

- Pointing is the implementing of joints to a depth of 10 mm to 20 mm and filling it with better quality mortar in desired shape.
- It is done for cement mortar and lime mortar joints. In exposed masonry, joints are considered to be the weakest and most vulnerable spots from which rainwater or dampness can enter.

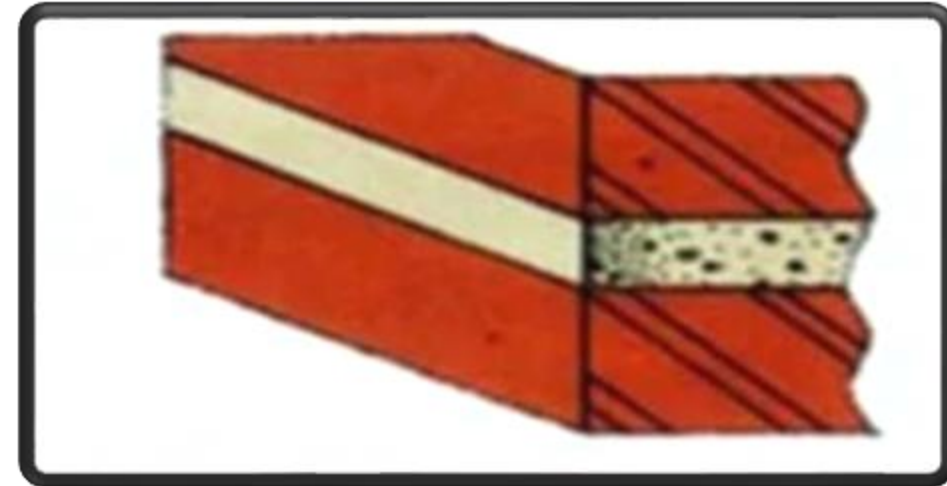


PLASTERING	POINTING
It is applied to entire surface.	It is provided only at exposed joints.
It provides smooth surface.	It does not provide smooth surface.
It conceals defective workmanship in the masonry construction	It is used to expose beauty of well built masonry work.
It provides a base for applying white/ colour washing	White washing or colour washing are ruled out.

- ***TYPES OF POINTING***

1. ***Flush Pointing:-***

- In this type, mortar is pressed hard in the raked joints and by finishing off flush with the edge of masonry units. The edges are neatly trimmed with trowel and straight edge.
- It does not give good appearance. But, flush pointing is more durable because of resisting the provision of space for dust, water etc., due to this reason, this method is extensively used.



2. ***Recessed Pointing:-***

In this case, mortar is pressing back by 5mm or more from the edges. During placing of mortar the face of the pointing is kept vertical, by a suitable tool. This type gives very good appearance.



3. ***Beaded Pointing:-***

It is formed by a steel or ironed with a concave edge. It gives good appearance, but it will damage easily when compared to other types.



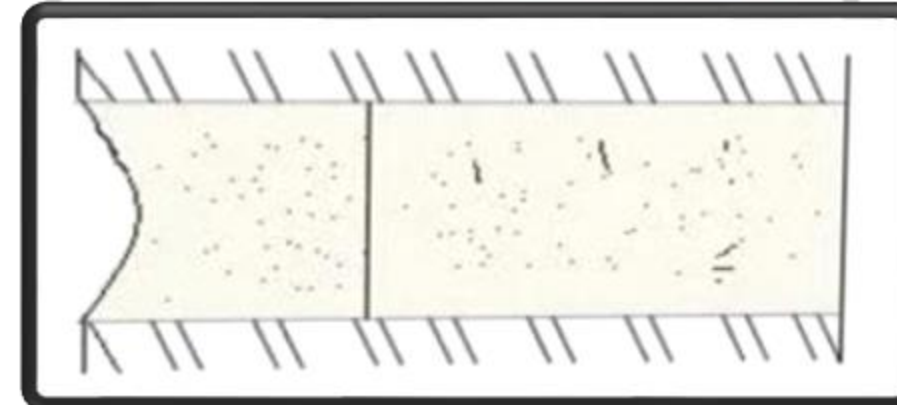
4. Struck Pointing

- This is a modification of flush pointing in which the face the pointing is kept inclined, with its upper edge pressed inside the face by 10mm which drains water easily.



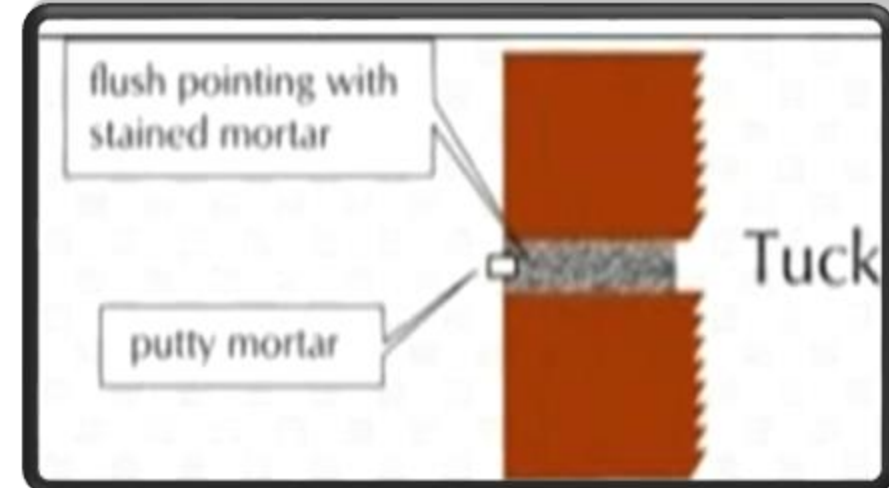
5. Rubbed, Keyed or Grooved Pointing

- This is also a modification of flush pointing in which groove is formed at its mid height, by a pointing tool. It gives good appearance.



6. Tuck Pointing

- In this case mortar is pressed in the raked joint first and finishing flush with the face. While the pressed mortar is green, groove or narrow channel is cut in the center of groove which is having 5mm width and 3mm depth.
- This groove is then filled with white cement putty, kept projecting beyond the face of the joint by 3 mm. if projection is done in mortar, it is called bastard pointing or half tuck pointing.

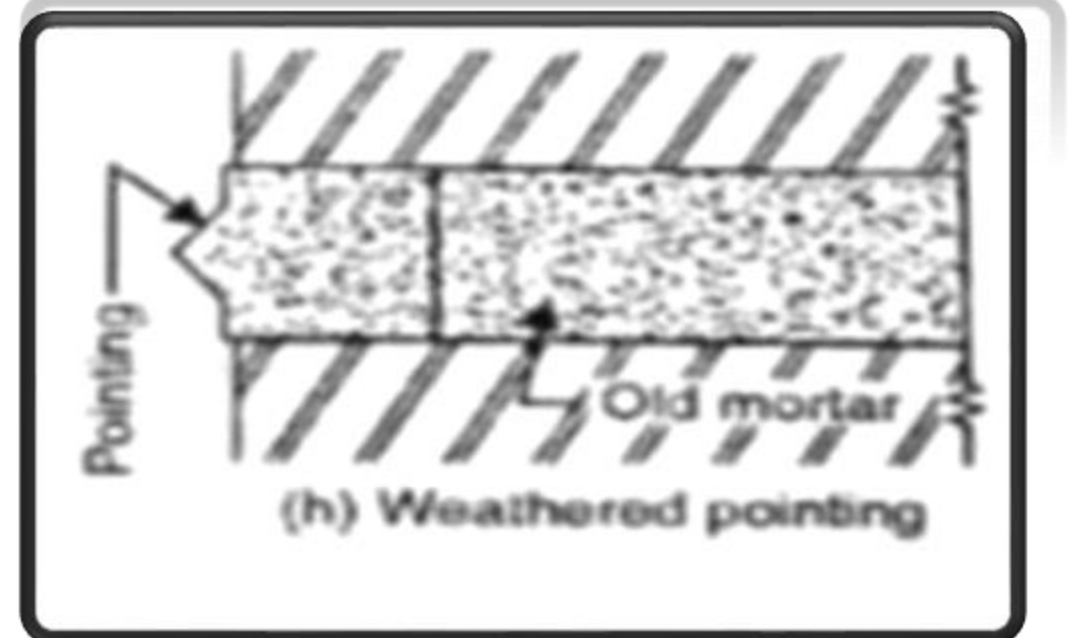
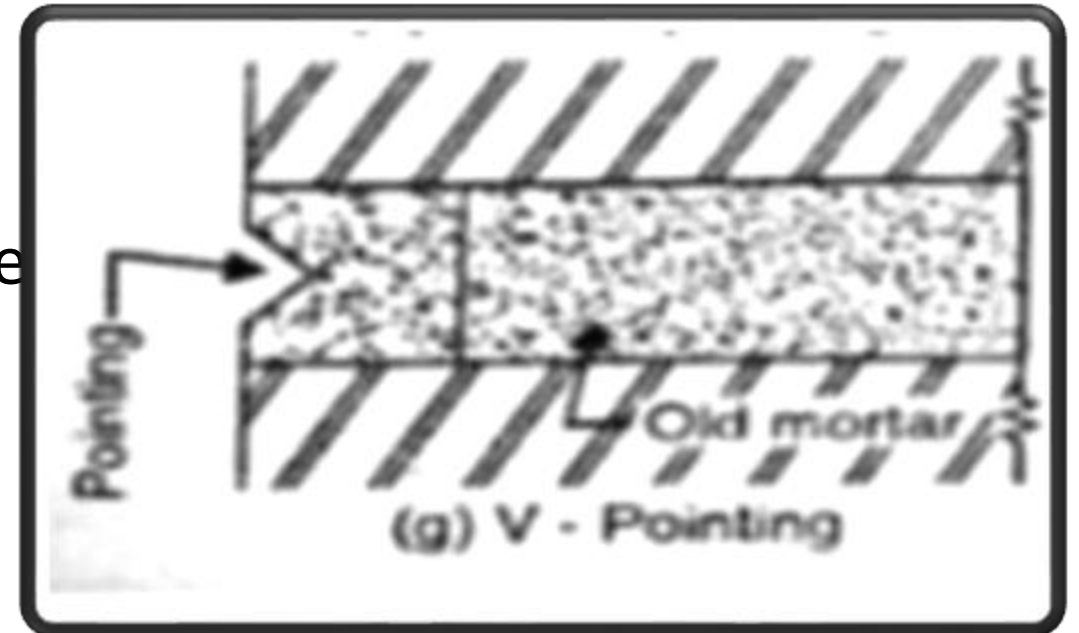


7. *V- Pointing:-*

This is formed by forming V-groove in the flush-finishing face.

8. *Weathered Pointing:-*

This is made by making a projection in the form of V-shape.



The objectives of painting are as under.

- It protects the surface from weathering effects and effect of other gases and fumes.
- It prevents decay of wood and wood based products.
- It prevents corrosion in metals used in dairy plants.
- It gives good appearance to the surface.
- Painting makes the surface smooth for easy cleaning.
- It makes the surface hygienically good, clean and attractive.

Pre Painting Process

- Ensure sufficient curing has been done to the walls. Minimum 7-21 days.
- Check the surface for any leakage or dampness. If you found any such problems rectify them before starting to paint. Allow them to dry
- Fill up any cracks. It should be treated with recommended crack filling process.
- Fill up any nail holes with primer and cover the switch box with sand.
- Make sure to remove all the movables from the room. If you can't, place it in the center of the room and cover them.
- Ensure to cover the floorings.

Surface Preparation

- Cleaning – Clean the wall area. It should be free from dust.
- Ensure to scrub off all the old paintings and loose plaster batches If you are painting an old wall surface.
- Scrub with sand papers to give a dry finish.
- Cover all the parts of the building that should be free from paint splatter such as doors, windows, switch boxes, furniture etc.

Exterior Painting

Pre Painting Process

- Ensure there is no leakage on the walls.
- Ensure there are no cracks on the walls. If you found any cracks rectify them using recommended the crack filling process. Give them proper time to dry.
- Ensure all the external wall plastering process has been completed fully. No batch works.
- Make sure to paint the wall from the top.
- Ensure all the staging requirements are provided.
- Ensure the safety of painting labors.
- Avoid any material transportation during the painting process.

Surface Preparation

- Ensure the wall had sufficient curing time. 35 -50 days.
- Ensure the wall is fully dried. Avoid painting on wet walls.
- Ensure the openings of drainage pipes and scaffolding gaps are filled.
- Make sure to cover the doors and windows to avoid paint splatter all over them.
- Painting
 - Exterior Wall Primer – Apply one coat of recommended exterior wall primer.
 - Paint – Apply 2 coats of paint. Allow 4-6 hours of time between the coats.



Wood Painting

- Normally wooden surface required different types of finishes according to the client need. There are many types of paints for different uses and applications. So make sure to understand the requirement. Below is just an outline process

Painting

- Make sure to remove any dust and dirt.
- Scrub the old wood finishes by sand paper.



Wood Primer (1st Coat) – Mix the thinner with the wood primer to the recommended ratio and apply one coat. Allow them to dry (6-8 hours)

- Putty – Generally 2 coats of primer will be applied on woods. Apply one coat of Putty or Lambi and allow them to dry.
- Wood Primer Primer (2nd Coat)– Sand the applied the surface and start to paint the second coat of putty.
- Enamels – Now apply the enamel on the wood surface. Allow them to dry.
- Paint – Now apply 2 coats of paint on the surface.

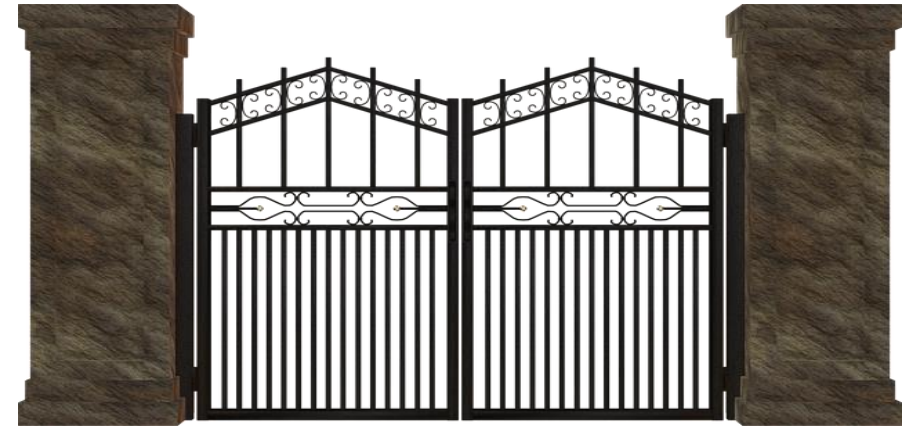
Metal Surface Painting

Surface Preparation

- Clean the metal surfaces by water to wipe off any dirt and grease or oil things.
- Ensure that the metal surface is free from rust.
- Sand the surface with sandpaper.
- Scrub off rust from the metal

Painting

- Metal Primer – Apply one coat of metal primer. Allow them to dry
- Sanding – Sand the primer and make sure the surface is clean
- Enamel – Apply 2 coats of recommended enamels. Make sure to give proper time to dry between coats



WHITE-WASHING complete process of white-washing can be carried out under the following operations:

1. Preparation Of white-wash

2. Preparation of surface, and

3. Application of white-wash

1. preparation of White-Wash

- To prepare white-wash. fresh lime is slaked at site of work and is dissolved in a tub with sufficient quantity of water. After slaking. it is allowed to remain in the tub of water for two days and then stirred up with a pole until it attains the consistency Of thin cream. This mixture is then strained or screened through a clean coarse cloth.
- Clean, gum dissolved in hot water is then added at the rate of 2 kg per m³ of lime (or 4 kg per m of thin cream or white wash-water) to the white-wash water. The solution so formed is called as "white wash". Sometimes. a part or whole of the gum may be replaced by the rice.
- To prevent the glare effect due to white-wash. sometimes. the copper sulphate at the rate of 4 kg/m of thin cream is added. In order to have better adhesive properties. alum or common salt may be added in the same proportion as gum,

2. Preparation of surface

- Before applying white-wash to new wall surface it must be cleaned, brushed and made free from loose material.
- If old surface to be rewhitewash then it must be scrapped off.
- All greasy spots should be given a coat of a mixture of rice water and sand so that the finishing wash may stick to the surface
- If white-wash to be done on a discoloured or smoke or in kitchen wall surfaces then it should given a wash of wood ash and water or yellow earth.

3. Application of white wash:-

- The whitewash is applied to a specified number of coat with a jute brush. Usually 3 coat are required for new work and scrapped surfaces, while one or two coats are considered sufficient for old work.
- For each coat one stroke is given from the top downward and the other from bottom upward over 1st stroke.
- Each coat should allowed to dry before applying next coat.

COLOUR WASHING

- A colour wash is usually prepared by adding the necessary colouring pigments in suitable the screened white-wash or liquid mixture of white-wash. It should be ensured that the quantities pigment is not affected by the presence Of lime. stirred The with colour-wash a stick during is applied the use. in exactly The quantity similar of white-wash. The colourwash is constantly wash. which is just enough for the day's work. should be prepared at a time in the morning the different colours can be prepared as follows:
- **Buff colour wash.** This is prepared by mixing sufficient quantity of earth and white-wash solution and then screening through the clean cloth.
- **Blue colour wash.** This is obtained by adding brunt coconut shells with the white-wash solution
- **Yellow colour wash.** This is obtained by adding yellow earth or ochre with the white solution.
- **Slate-colour wash.** This is obtained by adding lampblack and blue (i.e. copper sulphate) in suitable quantities in the white-wash solution.
- **Green-colour wash.** This is obtained by mixing solutions of boiled mango-bark in water of white-wash and of tootia (i.e. copper sulphate) in water, in certain proportions.
- **Pink-colour wash.** This is obtained by adding vermillion with the white wash.

Termite Proofing Materials

Chemicals for anti-termite treatment available in the market under the brand names **Durmet** that consist **Chloropyrifos concentrate 1.0% by weight** and **Dursban TC**.

The other chemicals like Aldrin, DDT can prevent the growth of termites, but these chemicals pose significant health hazards for human beings.

However, many of these chemicals are now banned under IS code, and the following emulsifiable chemicals are recommended:

Heptachlor concentrate: 0.5% by weight

Chlorpyrifos concentrate: 1.0% by weight

Chlordane concentrate: 1.0% by weight

Pre-Construction Treatment for Termite-Proofing

Anti-termite treatment should start when the pits are ready to **prevent the entry of subterranean termites into the buildings** by creating a chemical barrier in the soil surrounding the construction premises. The various stages of anti-termite treatment carried out are as follows:

Stage 1 - During the **site clearance**, the termite hills found at the site location should be sprayed with chemicals.

Stage 2 - Bottom and sides of trenches up to a height of 300 mm should be **treated with Durmet solution** at the rate of 5 litres per square metre of surface area.

Stage 3 - The refilled earth in contact with walls and columns should be treated with anti-termite chemicals for a width of 300 mm. About 3 to 5 litres per linear metre of the vertical surface should be used.

Stage 4 - After filling the earth up to plinth level for flooring, 50 to 70 mm deep holes should be drilled at 150 mm grid pattern. Treat these holes with the chemical solution at the rate of about 5 litres per square metre area.

Stage 5 - The **junction of walls and floors** should be treated at the rate of 15 litres per square metre of the wall surface.

Stage 6 - After the completion of construction, holes 300 mm deep should be drilled along the external perimeter of the building at an interval of 150 mm. The holes should be filled with chemicals at the rate of 5 litres per metre length.

Stage 7 - Expansion joints and perimeters of **pipes and conduits should also be treated with anti-termite chemicals**.

Stage 8 - Before installing windows and doors in contact with masonry should be coated with two layers of paint.

Post Construction Treatment for Termite-Proofing

If termite growth is found in any building, post-construction treatment is required for termite-proofing. Pressure pumps are used to ensure proper chemical penetration, and the procedures are described below:

Outside walls around the building: If **flagging concrete** is present around the building, then holes of diameter 12 mm are drilled at distances of 300 mm and a chemical solution is pumped inside the holes. If there is **no flagging concrete**, then 500 mm deep holes are drilled at distances of 150 mm using iron rods and filled with chemicals.

Soil under floor: **For treating floor, walls, construction joints, cracks, etc..**, holes of diameter 12mm are made 300 mm apart. These holes are pumped into soak the soil with a chemical solution of about 1 litre.

Treatment at plinth level: The holes are drilled on both sides of the wall at plinth level at an angle of 45° and a distance of 300 mm from the centre. The chemical solution is pumped in and after they are **sealed with cement mortar** in proportion 1:2.

For better protection from termites, structural barriers can be provided with **concrete or with metal sheets**. Concrete barriers are more durable than metal barriers as they are likely to fail due to **corrosion** or other damage. Concrete barriers can be of 50-75 mm thick concrete extending about 50-75 mm on both sides of the plinth.

Termites have the potential to damage your building significantly. So, termite-proofing services are highly essential for any building to eliminate and dismantle termites attack and protect the wood interiors of the building



DAMP PROOFING MATERIALS AND METHODS:-

- **Membrane damp proofing**

- In this method of damp proofing a [water](#) repellent membrane or damp proof course(D.P.C.) is introduced in between the source of dampness and the part of building adjacent to it. Damp proofing course may consist of flexible materials such as bitumen, mastic asphalt, bituminous felts, plastic or polythene sheets, metal sheets, [cement](#) concrete.
- Damp proofing course may be provided either horizontally or vertically in floors, walls etc. Provision of Damp Proofing Course in basement is normally termed as 'Tanking'.

- **Integral damp proofing**

- In the integral damp proofing method certain [water](#) proofing compounds are added to the concrete mix, so that it becomes impermeable. The common [water](#) proofing compounds may be in the following three forms.
- Compounds made from chalk, talc, fullers earth, which may fill the voids of concrete under the mechanical action principle.
- Compounds like alkaline silicates, aluminum sulphate, calcium chlorides, etc. which react chemically with concrete to produce [water](#) proof concrete

- **Surface treatment**

- Moisture finds its way through the pores of material used in finishing. In order to check the entry of the moisture into the pores, they must be filled up. In the surface treatment method a layer of [water](#) repellent substances or compounds are applied on these surfaces through which moisture enters.
- The use of [water](#) repellent metallic soaps such as calcium and aluminum oletes and stearates are much effective against rain [water](#) penetration.
- [Pointing](#) and plastering of the exposed surfaces must be done carefully, using [water](#) proofing agents like sodium or potassium silicates, aluminum or zinc sulphates, barium hydroxide and magnesium sulphates etc.

- **Cavity wall construction**

- Cavity wall construction is an effective method of damp prevention. In this method the main wall of a building is shielded by an outer skin wall, leaving a cavity between the two. The cavity prevents the moisture from travelling from the outer to the inner wall.

- **Guniting**

- In this method of damp proofing, an impervious layer of rich [cement mortar](#) is deposited under pressure over the exposed surfaces for [water](#) proofing or over pipes, cisterns etc. for resisting the [water](#) pressure. The operation is carried out by use of a machine known as [cement](#) gun.
- The [cement](#) gun consists of a machine having arrangements for mixing materials and a compressor for forcing the mixture under pressure through a 50 mm dia flexible hose pipe.
- The hose pipe has nozzle at its free end to which [water](#) is supplied under pressure through a separate connection. The surface to be treated is first thoroughly cleaned of dirt, dust, grease or loose particles and wetted properly.

- **Pressure grouting**

- This consists of forcing [cement](#) grout under pressure, into cracks, voids, fissures and so on present in the structural components of the building, or in the ground. Thus the structural components and the foundations which are liable to moisture penetration are consolidated and are thus made [water](#)-penetration-resistant.
- This method is quite effective in checking the seepage of raised ground [water](#) through foundations and sub-structure of a building

Materials for damp proof course

Following are the materials generally used for damp proofing of structures:

1) Flexible Materials for Damp Proof Course

The materials, which do not crack and deform their shape when subjected to loading, are called Flexible Materials

a) Bitumen Mastic (Mastic Asphalt)

It consists of asphalt or bitumen mixed with fine sand in hot state to form an impervious mass.

Due to this consistency it can be spread (when hot) to a depth of 2.5cm to 5cm, which sets on cooling.

It provides good impervious layer but special care is needed in its laying.

b) Bitumen Felts (Sheets)

It consists of 6mm thick sheet of bitumen prepared in rolls having width equal to that of brick wall.

c) Hot laid Bitumen

This material is used on a bedding of cement concrete or mortar.

This should be applied in two layers at the rate of 1.75kg/m^2 of the area.

d) Metal Sheets

Metal sheets of Copper, Aluminium, or Lead are used to prevent dampness, but they are costly.

Sheets of these materials are used throughout the thickness of the wall.

The sheets of Lead are laid over Lime Mortar and not with [Cement](#).

Mortar due to the chemical reaction of Cement over the Lead.

The sheets of metal should be coated with asphalt.

The thickness of the sheets should not be less than 3mm.

2) Rigid Materials for Damp Proof Course

The materials, which do not resist transverse stresses and cracks when subjected to sever loading, are known as Rigid Materials.

a) Rich Concrete

1.2cm to 4cm thick layer of Rich Concrete (1:2:4) painted with two coats of hot bitumen is used as horizontal D.P.C.

It also prevents the moisture penetration by capillary action.

These layers are laid where the damp is not excessive.

b) Mortar:

2cm thick layer of Rich Cement and Sand Mortar (1:3) is applied on the inner face of external wall.

This is a vertical D.P.C.

The surface is then painted with two coats of hot bitumen.

c) Bricks:

Over burnt or dense bricks in one or two layers can be used as cheap and effective DPC.

They are laid in Rich Cement and Sand Mortar (1:3).

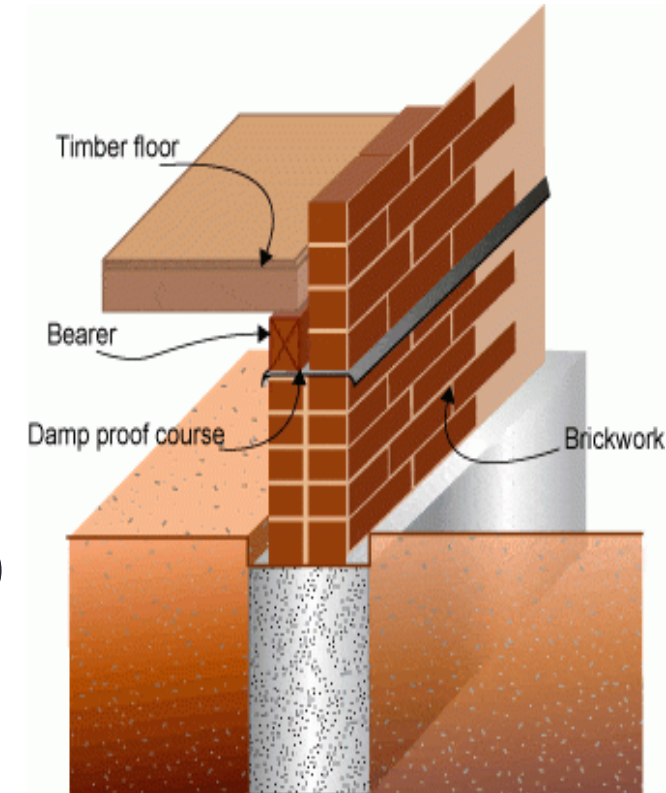
Bricks are rarely used as DPC except in cheap houses.

d) Stones or Slates:

Two layers of stone slabs or slates laid in Lime, Cement and Sand Mortar (1:1:6) make a best DPC.

They can also be laid in Cement Sand Mortar.

It is used where a good quality of stone is easily and cheaply available.



Green buildings are designed to reduce the overall impact of the built environment on human health and natural environment by:

- Efficiently using energy, water and other resources.
- Protecting occupant's health and improving employee productivity.
- Reducing waste, pollution and environment degradation.

The green building concept is gaining importance in various countries. These are buildings that ensure that waste is minimized at every stage during the construction and operation of the building, resulting in low costs according to the experts in the technology.

What Makes a Building Green?

Following examples can be considered for green buildings:

- Green buildings may incorporate sustainable materials in their construction (e.g., reused, recycled content, or made from renewable resources).
- Create healthy indoor environments with minimal pollutants (e.g., reduced product emissions).
- And feature landscaping that reduce water usage (e.g., by using native plants that survive without extra watering).
- A green building is a structure that is environmentally responsible and resource-efficient throughout its life-cycle. These objectives expand and complement the classical building design concerns of economy, utility. Durability and comfort.

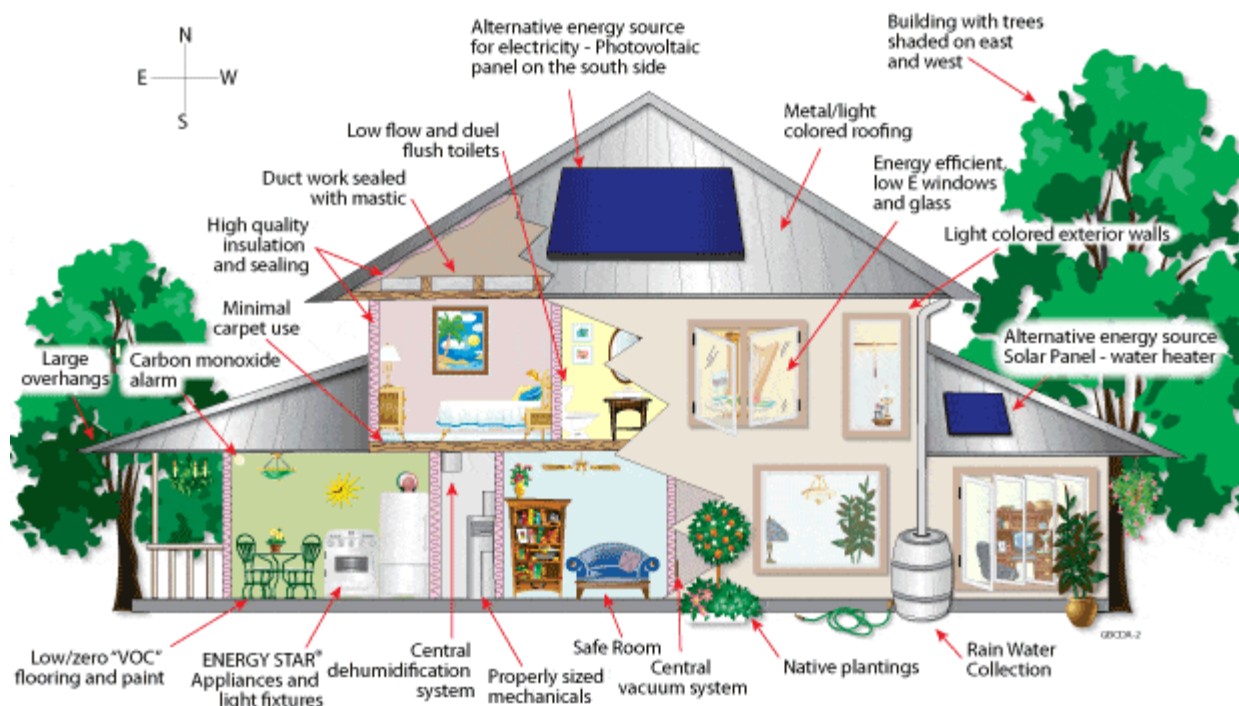


Fig: Components of a green building

What are Green Features of a Green Building?

- Minimal disturbance to landscapes and site condition
- Use of non-toxic and recycled / recyclable material
- Efficient use of water and water recycling
- Use of energy efficient and eco-friendly equipments
- Use of renewable energy
- Quality of indoor air quality for human safety and comfort
- Effective controls and building management system

A green building has four main elements or components on which it is designed: materials, energy, water and health to make green building more sustainable.

Elements of Green Building Design

Following are the components of a Green Building to make it sustainable:

1. Materials for Green Building

Materials for a green building are obtained from natural, renewable sources that have been managed and harvested in a sustainable way; or they are obtained locally to reduce the embedded energy costs of transportation; or salvaged from reclaimed materials at nearby sites.

Materials are assessed using green specifications that look at their Life Cycle Analysis (LCA) in terms of their embodied energy, durability, recycled content, waste minimisation, and their ability to be reused or recycled.

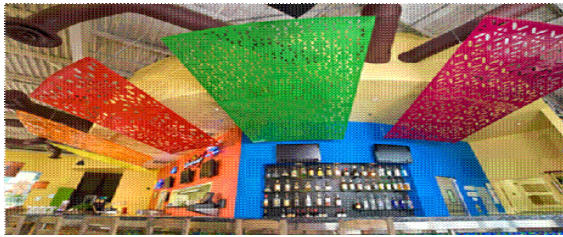


Fig: Parasoleil Recycled Content Panels

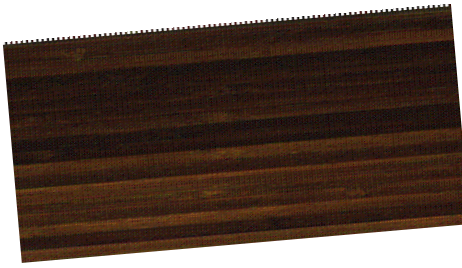
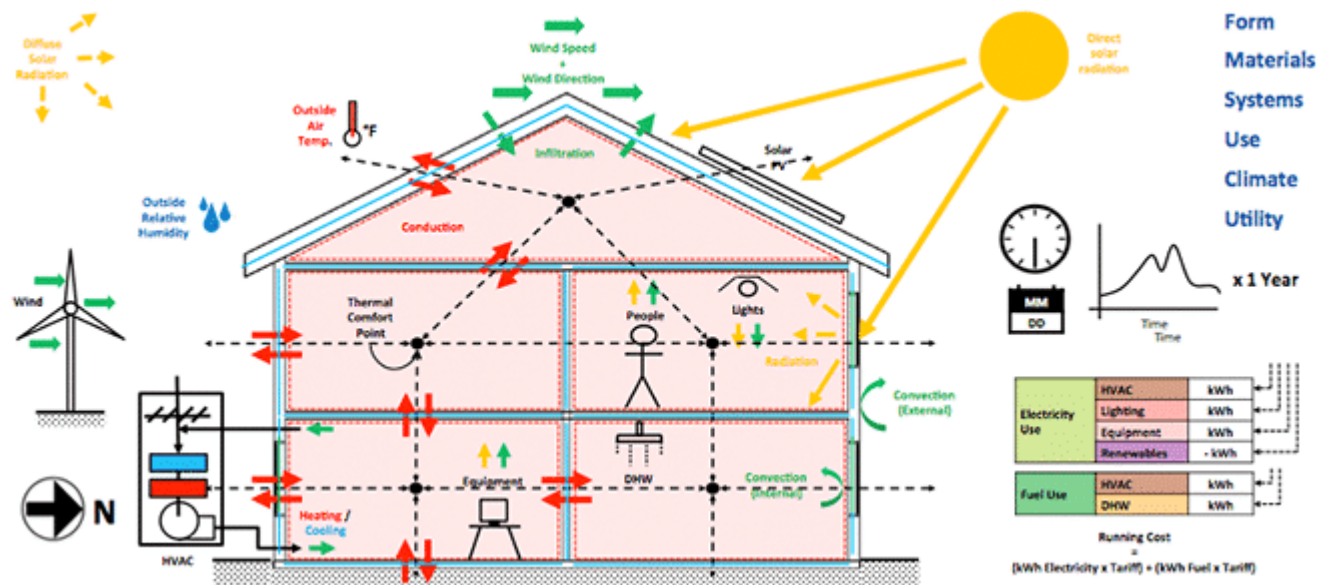


Fig: Chocolate bamboo

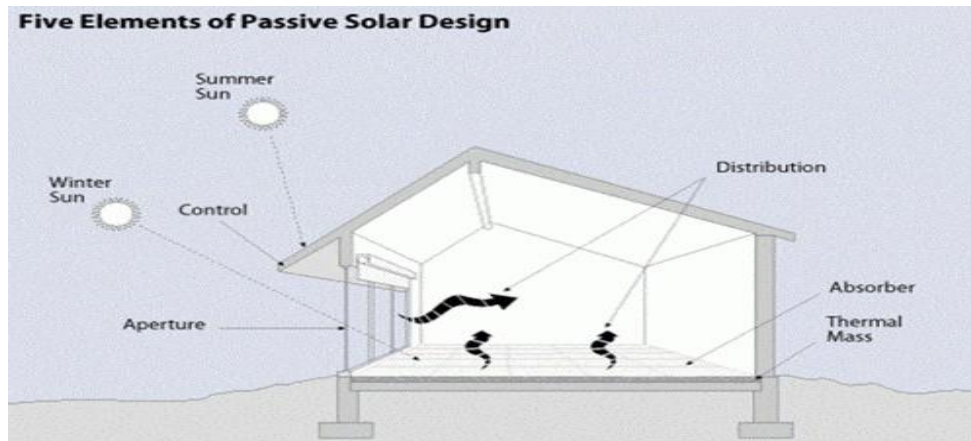
2 Energy Systems in Green Buildings

- Passive solar design will dramatically reduce the heating and cooling costs of a building, as will high levels of insulation and energy-efficient windows.
- Natural daylight design reduces a building's electricity needs, and improves people's health and productivity.
- Green buildings also incorporate energy-efficient lighting, low energy appliances, and renewable energy technologies such as wind turbines and solar panels.



2.1 Passive Solar Design

Passive solar design uses sunshine to heat, cool and light homes and other buildings without mechanical or electrical devices. It is usually part of the design of the building itself, using certain materials and placement of windows or skylights.



2.1a) Rules Of Passive Solar Systems

- The building should be elongated on an east-west axis.
- The building's south face should receive sunlight between the hours of 9:00 A.M. and 3:00 P.M. (sun time) during the heating season.

- Interior spaces requiring the most light and heating and cooling should be along the south face of the building. Less used spaces should be located on the north.

2.1b) The Advantages Of Passive Solar Design

- **High energy performance:** lower energy bills all year round.
- **Investment:** independent from future rises in fuel costs, continues to save money long after initial cost recovery.
- **Value:** high owner satisfaction, high resale value.
- **Attractive living environment:** large windows and views, sunny interiors, open floor plans.
- **Low Maintenance:** durable, reduced operation and repair.
- **Unwavering comfort:** quiet (no operating noise), warmer in winter, cooler in summer (even during a power failure).
- **Environmentally friendly :** clean, renewable energy doesn't contribute to global warming, acid rain or air pollution.

2.2 *Passive Solar Heating*

- The goal of all passive solar heating systems is to capture the sun's heat within the building's elements and release that heat during periods when the sun is not shining.
- At the same time that the building's elements (or materials) is absorbing heat for later use, solar heat is available for keeping the space comfortable (not overheated).

2.2a) Two primary elements of passive solar heating are required:

- South facing glass
- Thermal mass to absorb, store, and distribute heat.

2.2b) There are three approaches to passive systems

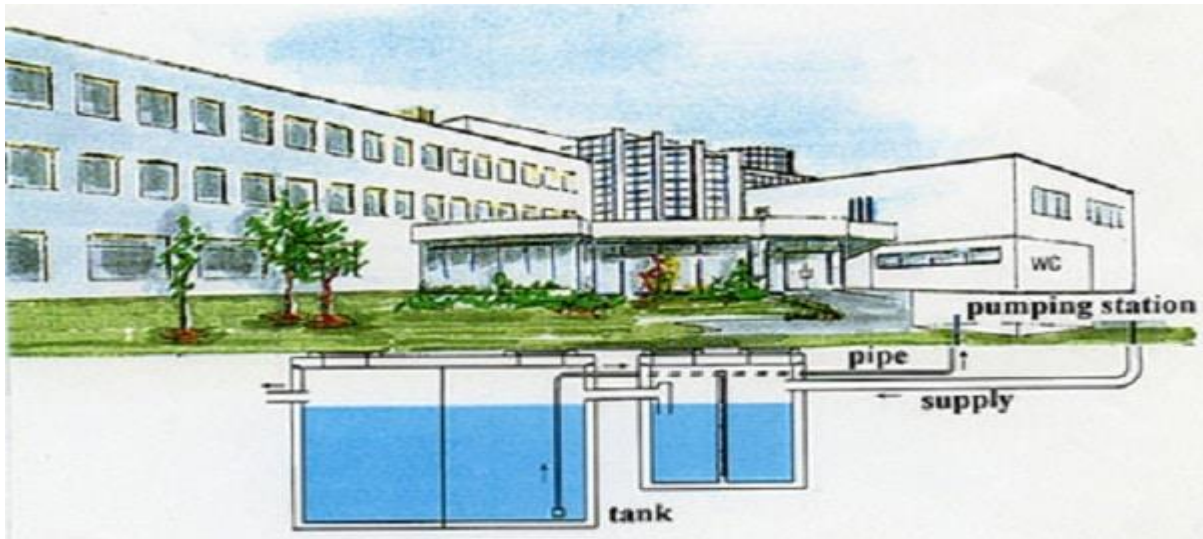
1. Direct Gain: Sunlight shines into and warms the living space.
2. Indirect Gain: Sunlight warms thermal storage, which then warms the living space.
3. Isolated Gain: Sunlight warms another room (sunroom) and convection brings the warmed air into the living space.

3. Water Management in Green Building

Minimising water use is achieved by installing greywater and rainwater catchment systems that recycle water for irrigation or toilet flushing; water-efficient appliances, such as low flow showerheads, self-closing or spray taps; low-flush toilets, or waterless composting toilets. Installing point of use hot water systems and lagging pipes saves on water heating.

3.1) Rainwater Harvesting in Green Building

- Rainwater harvesting is the principle of collecting and using precipitation from a catchments surface.
- An old technology is gaining popularity in a new way. Rain water harvesting is enjoying a renaissance of sorts in the world, but it traces its history to biblical times.
- Extensive rainwater harvesting apparatus existed 4000 years ago in the Palestine and Greece.
- In ancient Rome, residences were built with individual cisterns and paved courtyards to capture rain water to augment water from city's aqueducts.



3.2) Rainwater harvesting is essential

Surface water is inadequate to meet our demand and we have to depend on groundwater. Due to rapid urbanization, infiltration of rainwater into the subsoil has decreased drastically and recharging of groundwater has diminished.

As you read this guide, seriously consider conserving water by harvesting and managing this natural resource by artificially recharging the system.

3.3) Rainwater Harvesting Techniques for Green Buildings

There are two main techniques of rainwater harvestings.

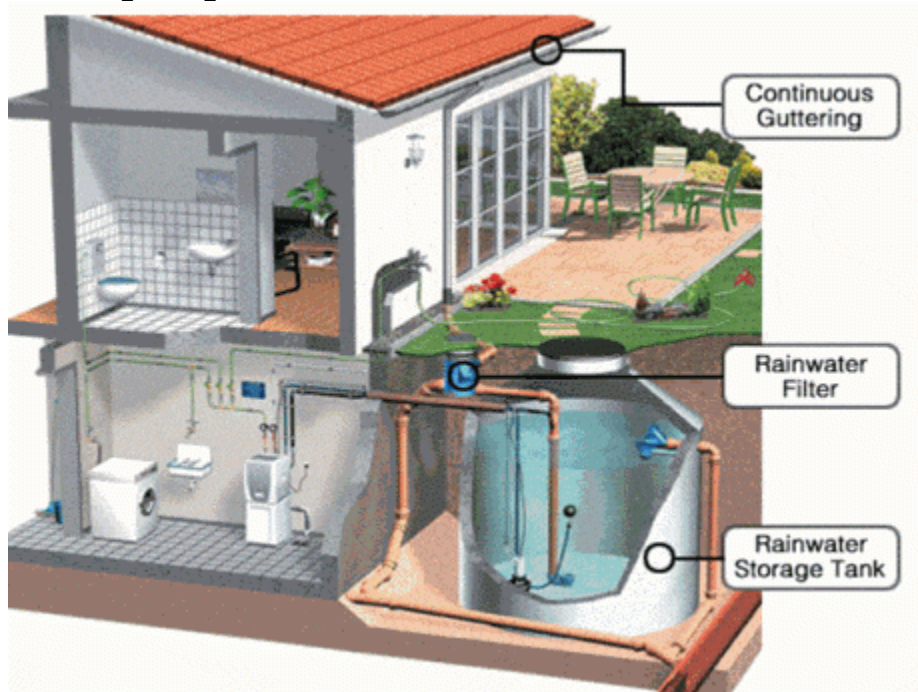
1. Storage of rainwater on surface for future use.
2. Recharge to groundwater

3.3.a) Storage of rainwater on surface for future use.

The storage of rainwater on surface is a traditional techniques and structures used were underground tanks, ponds, check dams, weirs etc.

3.3.b) Recharge to groundwater:-

Recharge to groundwater is a new concept of rainwater harvesting and the structures generally used are **Pits ,Trenches, Dug wells, Hand pumps, etc.**



4. Health Components of Green Building

- Using non-toxic materials and products will improve indoor air quality, and reduce the rate of asthma, allergy and sick building syndrome.
- These materials are emission-free, have low or no VOC content, and are moisture resistant to deter moulds, spores and other microbes.
- Indoor air quality is also addressed through ventilation systems and materials that control humidity and allow a building to breathe.



- In addition to addressing the above areas, a green building should provide cost savings to the builder and occupants, and meet the broader needs of the community, by using local labour, providing affordable housing, and ensuring the building is sited appropriately for community needs.

Why the Need for Energy Audit

- The three top operating expenses are energy (both electrical and thermal), labour and materials.
- Energy would emerge as a top ranker for cost reduction
- primary objective of Energy Audit is to determine ways to reduce energy consumption per unit of product output or to lower operating costs
- Energy Audit provides a "bench-mark" (Reference point) for managing energy in the organization

Types of Energy Audits

- Preliminary Energy Audit
- Targeted Energy Audit
- Detailed Energy Audit

Preliminary Energy Audit

- Preliminary energy audit uses existing or easily obtained data

- Find out the energy consumption area in the organization
Estimates the scope for saving
- Identifies the most likely areas for attention
- Identifies immediate(no cost or low cost) improvements Sets a 'reference point'
- Identifies areas for more detailed study/measurement.

Targeted Energy Audits

- Targeted energy audits are mostly based upon the outcome of the preliminary audit results.
- They provide data and detailed analysis on specified target projects.
- As an example, an organization may target its lighting system or boiler system or compressed air system with a view to bring about energy savings.
- Targeted audits therefore involve detailed surveys of the target subjects/areas with analysis of the energy flows and costs associated with those targets.

Detailed Energy Audit

- Detailed Energy Audit evaluates all systems and equipment which consume energy and the audit comprises a detailed study on energy savings and costs.
- Detailed Energy Audit is carried out in 3 phases
 - The Pre-audit Phase
 - The Audit Phase
 - The Post-Audit Phase